BASINWIDE ASSESSMENT REPORT

WATAUGA RIVER

NORTH CAROLINA
DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
Division of Water Quality
Water Quality Section
Environmental Sciences Branch

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EXECUTIVE SUMMARY

This document presents a water quality assessment of the Watauga River basin. Monitoring programs covered within this report include benthic macroinvertebrates, ambient water quality, and aquatic toxicity for the period 1994 - 1999. Studies conducted prior to and including 1994 were previously summarized in NCDEHNR (1996).

In general, the document is structured such that the one subbasin is physically described and an overview of water quality is given. General water quality conditions are presented in an upstream to downstream format. The Watauga River subbasin is described by a six digit code (040201), but is often referred to by its last two digits (e.g. Subbasin 01).

The Watauga River basin is the second smallest (205 mi^2) river basin in the state. It has about 303 miles of streams and rivers. The basin is located in the northwest mountains (in the Blue Ridge physiographic province) in Watauga and Avery counties (Figure 1). The Watauga River and Elk River are headwater tributaries of the Holston River system and flow northwest from North Carolina into Tennessee. These waters flow into the Tennessee River, and eventually into the Mississippi River and the Gulf of Mexico.

This basin contains the municipalities of Banner Elk, Beech Mountain, Elk Park, Seven Devils, and Sugar Mountain, as well as the western portion of Boone. Over 50% of the basin is forested, with another 25% devoted to pastureland. Portions of the basin are being rapidly developed for second homes and recreational activities. Much of this development is focused on stream and river corridors, potentially affecting water quality through both nonpoint source runoff and numerous small point source dischargers.

The upper portion of the Watauga River, and most tributaries, support a good trout fishery. This intergrades with a "cool-water" fishery (smallmouth bass) in the middle and lower section of the river.

Overall, water quality in this basin is very high, with the majority of sites having a bioclassification of Good or Excellent, based on macroinvertebrate data collected in 1999. Benthos sites did not change bioclassifications from the 1994 basin assessments, with the exception of the Watauga River near Foscoe, which went from Excellent to Good-Fair.

The entire Watauga River was classified as High Quality Waters in 1990, although the 1999 macroinvertebrate collections indicated only Good-Fair water quality in the upper segment near Foscoe and Good water quality in the middle portion near Sugar Grove. Excellent ratings, however, were still assigned to the Shulls Mill and Peoria sites. Boone Fork and tributaries were classified as Outstanding Resource Waters in 1993. A benthos site on Boone Fork above Price Lake continued to be rated as Excellent in 1999.

Some of the watersheds in the basin are intensively farmed, especially Cove Creek, Beaverdam Creek and Laurel Creek. Based upon the 1999 macroinvertebrate data, nonpoint source runoff appeared to cause minor impacts resulting in Good ratings in a segment of the Watauga River, a part of the Elk River, Cove Creek, and Laurel Creek.

There are three ambient water quality monitoring stations and all are located on the Watauga River. Dissolved oxygen concentrations were greater than 6.0 mg/l at all stations since 1980 and greater than 7.0 mg/l during this assessment period (September 1, 1994 to August 31, 1999). The monitoring station at Sugar Grove showed an improvement for fecal coliform bacteria. Turbidity remained low at all stations. No temporal patterns were noted for nutrients.

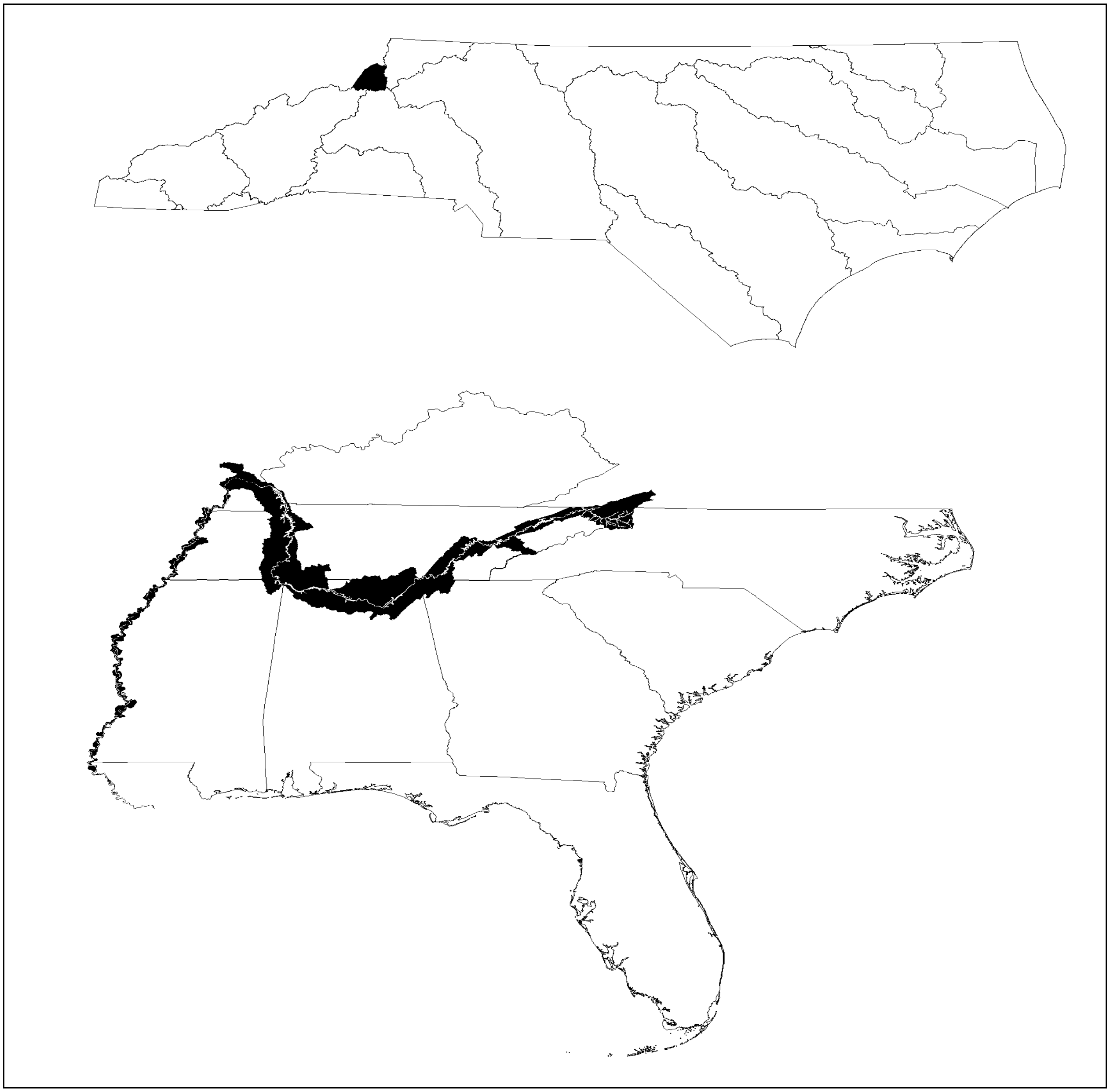

Figure 1. Geographical relationships of the Watauga River basin to the Tennessee River and lower Mississippi River drainages.

EXECUTIVE SUMMARIES BY PROGRAM AREA

BENTHIC MACROINVERTEBRATES

Bioclassifications and Water Quality Changes

Water quality in the Watauga River basin, as assessed using benthic macroinvertebrates, is generally Good or Excellent (Figure 2). Sixty-three samples have been collected since 1983 and 90% of these have rated the sites either Good or Excellent. No sites have ever been rated Fair or Poor.

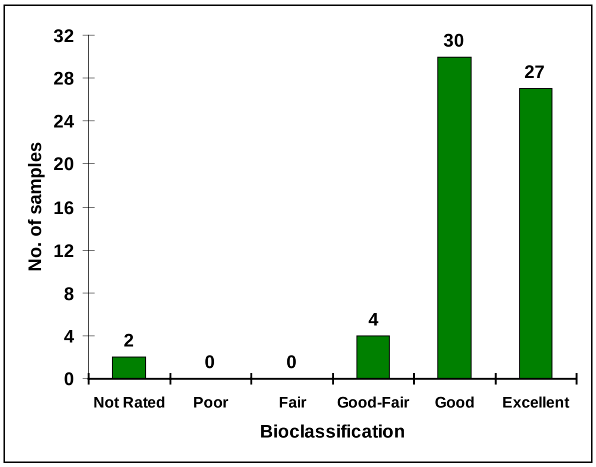

Figure 2. Bioclassifications of 63 samples collected from the Watauga River basin, 1983 - 1999.

In 1999, 13 sites were rated as part of the basinwide monitoring (Figure 3).

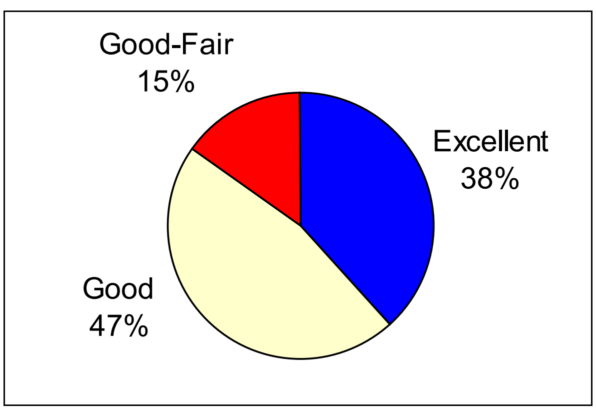

Figure 3. Bioclassifications of 13 ratable sites in the Watauga River basin, 1999.

The bioclassifications in the basin have not changed appreciably since the last monitoring cycle (Figure 4) and have not changed appreciably since 1983.

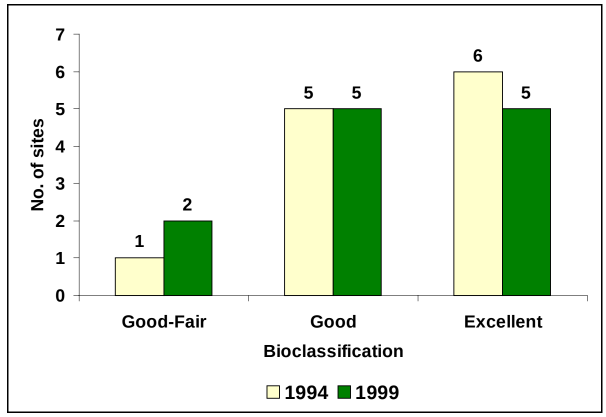

Figure 4. Bioclassifications of the same 12 sites rated in 1994 and 1999 in the Watauga River basin.

The only exception to this was the upper Watauga River at Foscoe. Here, the bioclassification decreased from Excellent to Good-Fair. The decline was attributed to unknown nonpoint source runoff, rather than to point sources.

Long-term changes in water quality (> 5 years of data) were evaluated at eight sites (Figure 5). These data indicated a decline in the upper Watauga River and in Boone Fork below Price Lake. The lower Watauga River, however, changed from Good in 1988 to Excellent in 1994 and 1999.

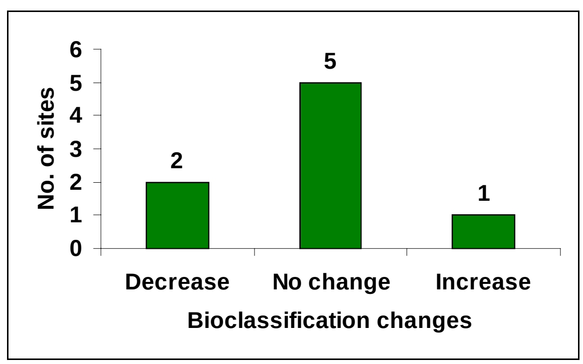

Figure 5. Changes in bioclassifications at eight sites in the Watauga River basin, 1983 - 1999.

Benthic Macroinvertebrate Fauna Distributional Records

Several rare or unusual invertebrate species were collected during the 1999 surveys:

- Beech Creek is the only North Carolina locality for the intolerant caddisfly *Ceratopsyche walkeri*.
- Biotic Index values indicated that upper Boone Fork had the most intolerant community, including two species of *Drunella, Nixe*, and *Symphitopsyche macleodi*.
- *Potamanthus distinctus* was recorded in the Watauga River from Shulls Mill to Peoria, with large populations also present in Cove Creek and Beaverdam Creek.
- The Watauga River at Peoria had the highest number of invertebrate taxa, including 24 mayfly and 21 caddisfly taxa. Unusual taxa at this site included *Baetis armillatus*, *Ephoron leukon*, *Micrasema rickeri*, and *Protoptila.*

FISHERIES

Fish Community Assessment

Twenty nine species have been collected from the basin in North Carolina (Menhinick 1991, TVA 1996). None of the species are considered rare, endangered, or threatened at the state or national level (LeGrand and Hall 1999; Menhinick and Braswell 1997).

The North Carolina Index of Biotic Integrity is one of the tools the NCDWQ uses which summarizes all classes of factors such as water and habitat quality, flow regime, and energy sources which influence the freshwater fish communities of wadeable streams throughout the state. No stream fish community basinwide monitoring was conducted during 1999 in the Watauga River basin because of recent revisions and a reexamination of the criteria and metrics.

Fish Tissue Contaminants

No fish tissue contaminant monitoring was conducted between 1995 and 1999 because of the lack of any significant contaminant issues in the basin.

Fish Kills

The Division has systematically monitored and reported on fish kill events across the state since 1996. Only one fish kill event was reported for the Watauga River basin from 1994 to 1999. In 1999, a private citizen illegally rinsed out three 55 gallon drums of Percol (a chemical flocculent) into Sharp Creek near Amantha killing approximately 120 brook trout, brown trout, and bluehead chub (NCDENR 1999). The citizen was required to pay $475 in fish replacement costs that were calculated by the North Carolina Wildlife Resources Commission. Information on fish kills in other basins may be found on the Division's website (refer to the Glossary).

LAKE ASSESSMENT

No lakes in the basin were monitored by the Division between 1995 and 1999.

AMBIENT MONITORING SYSTEM

There are three ambient water quality monitoring stations in the basin and all are located on the Watauga River. Each site is supplementally classified as Class B, Trout, and High Quality Waters. These stations are sampled monthly for 27 parameters. Important findings during the recent monitoring cycle include:

- Dissolved oxygen concentrations were greater than 6.0 mg/l at all stations since 1980 and greater than 7.0 mg/l during this assessment period.
- Conductivity increased slightly at the monitoring station near Shulls Mill with a concomitant increase in hardness and a decrease in pH. These patterns were corrected for flow and found to be not statistically significant.
- The geometric mean for fecal coliform bacteria ranged from 27 to 44 colonies/100 ml. The site at Sugar Grove showed an improvement for fecal coliform bacteria with the geometric mean decreasing from 135 colonies/100 ml for all data collected before June 29, 1989 to 44 colonies/100 ml for the data collected during the current assessment period.
- Turbidity remained low at all stations although four values ranged between 10 and 18 NTU at the station near Sugar Grove.
- No temporal patterns were noted for nutrients.
- Copper exceeded the action level (7 µg/l) in 14% of the 57 samples collected during this basinwide monitoring cycle.

AQUATIC TOXICITY MONITORING

Two facilities have NPDES permits which require whole effluent toxicity monitoring. These facilities are Beech Mountain and Sugar Mountain Utilities. Since 1991, all facilities have been operating within a compliance rate greater than 90%.

INTRODUCTION TO PROGRAM METHODS

The Division uses a basinwide approach to water quality management. Activities within the Division, including permitting, monitoring, modeling, nonpoint source assessments, and planning are coordinated and integrated for each of the 17 major river basins within the state. All basins are reassessed every five years, and the Watauga River basin was sampled by the Environmental Sciences Branch in 1994 and 1999.

The Environmental Sciences Branch collects a variety of biological, chemical, and physical data that can be used in a myriad of ways within the basinwide planning program. In some areas there may be adequate data from several program areas to allow a fairly comprehensive analysis of ecological integrity or water quality. In other areas, data may be limited to one program area, such as only benthic macroinvertebrate data or only fisheries data, with no other information available. Such data may or may not be adequate to provide a definitive assessment of water quality, but can provide general indications of water quality. The primary program areas from which data were drawn for this assessment of the Hiwassee River basin include benthic macroinvertebrates, lake assessment, ambient monitoring, and aquatic toxicity monitoring.

BENTHIC MACROINVERTEBRATES

Benthic macroinvertebrates, or benthos, are organisms that live in and on the bottom substrates of rivers and streams. These organisms are primarily aquatic insect larvae. The use of benthos data has proven to be a reliable monitoring tool, as benthic macroinvertebrates are sensitive to subtle changes in water quality. Since many taxa in a community have life cycles of six months to one year, the effects of short term pollution (such as a spill) will generally not be overcome until the following generation appears. The benthic community also integrates the effects of a wide array of potential pollutant mixtures.

Sampling methods and criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample from flowing waters based on the number of taxa present in the intolerant groups Ephemeroptera, Plecoptera and Trichoptera (EPT S) (Appendix B1). Likewise, ratings can be assigned with a North Carolina Biotic Index (NCBI). This index summarizes tolerance data for all taxa in each collection. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis. Different criteria have been developed for different ecoregions (mountains, piedmont and coastal) within North Carolina for freshwater flowing waterbodies.

Bioclassifications listed in this report (Appendix B2) may differ from older reports because evaluation criteria have changed since 1983. Originally, total taxa richness and EPT taxa richness criteria were used, then just EPT taxa richness, and now BI as well as EPT taxa richness criteria are used for flowing freshwater sites. Refinements of the criteria continue to occur as more data are gathered.

FISHERIES

Fish Kills

Fish kills investigation protocols were established in 1996 by the Division to investigate, report, and track fish kill events throughout the state. Fish kill and fish health data collected by trained Division and other resource agency personnel are recorded on a standardized form and forwarded to the Environmental Sciences Branch where the data are reviewed.

Fish kill investigation forms and supplemental information are compiled in a database where the data can be managed and retrieved for use in reporting to concerned parties.

AMBIENT MONITORING SYSTEM

Assessments of water quality can be obtained from information about the biological communities present in a body of water or from field and laboratory measurements of particular water quality parameters. This section summarizes the field and laboratory measures of water quality, typically referred to as ambient water quality measures.

The Ambient Monitoring System is a network of stream, lake, and estuarine stations strategically located for the collection of physical and chemical water quality data. Parametric coverage is tiered by freshwater or saltwater waterbody classification and corresponding water quality standards. Under this arrangement, core parameters are based on Class C waters with additional parameters appended when justified (Table 3).

Table 3. Freshwater parametric coverage for the ambient monitoring system.[1]

Parameter	All freshwater	Water Supply
Field		
Dissolved oxygen	x	x
pH	x	x
Conductivity	✔	✔
Temperature	✔	✔
Nutrients		
Total phosphorus	✔	✔
Ammonia as N	✔	✔
Total Kjeldahl as N	✔	✔
Nitrate + nitrite as N	✔	x
Other		
Total suspended solids	✔	.
Total dissolved solids	.	x
Turbidity	x	x
Hardness	✔	x
Chloride	✔	x
Bacteria		
Fecal coliform bacteria	x	x
Total coliform bacteria	.	x
Metals		
Aluminum	✔	✔
Arsenic	x	x
Cadmium	x	x
Chromium	x	x
Copper	x	x
Iron	x	x
Lead	x	x
Mercury	x	x
Nickel	x	x
Silver	x	x
Zinc	x	x
Manganese	.	x
Biological		
Chlorophyll *a*[2]	x	x

[1] A check (✔) indicates the parameter is collected; an 'x' indicates the parameter is collected and has a standard or action level.
[2]Chlorophyll *a* is collected in Nutrient Sensitive Waters (NSW).

Summaries of water quality parameters measured during the five year period (September 1, 1994 – August 31, 1999) are provided (refer to Tables 11-13). These tables present the number of samples collected and the number (and proportion) of samples greater than or less than a water quality reference value.

In addition, a description of how the data are distributed is provided using percentiles. Percentiles describe the proportion of observations less than a specific value or concentration. For example, the 50th percentile (also called the median) provides the value (or concentration) of the parameter in which one half (50%) of the observations lie.

The water quality reference value may be a narrative or numeric standard, or an action level as specified in the North Carolina Administrative Code 15A NCAC 2B .0200. Zinc is not included in the summaries for metals because recent (since April 1995) sampling or analyses may have been contaminated with zinc and the data may be unreliable.

In this report, conductivity is synonymous with specific conductance. It is given in micromhos per centimeter (µmhos/cm) at 25 ^{o}C.

AQUATIC TOXICITY MONITORING

Acute and/or chronic toxicity tests are used to determine toxicity of discharges to sensitive aquatic species (usually fathead minnows or the water flea, *Ceriodaphnia dubia*). Results of these tests have been shown by several researchers to be predictive of discharge effects on receiving stream populations.

Many facilities are required to monitor whole effluent toxicity by their NPDES permit or by administrative letter. Facilities without monitoring requirements may have their effluents evaluated for toxicity by the Division's Aquatic Toxicology Laboratory. If toxicity is detected, the Division may include aquatic toxicity testing upon permit renewal.

The Aquatic Toxicology Unit maintains a compliance summary for all facilities required to perform tests and provides a monthly update of this information to regional offices and Division administration. Ambient toxicity tests can be used to evaluate stream water quality relative to other stream sites and/or a point source discharge.

WATAUGA RIVER SUBBASIN 01

Description

The Watauga River basin is located in the mountain ecoregion, southwest of the New River basin (Figure 6). The basin contains the town of Banner Elk, as well as the western portion of Boone. The principal tributary of the Watauga River originating in North Carolina is the Elk River.

The upper portion of the Watauga River supports a good trout fishery; this intergrades with a "cool-water" fishery (smallmouth bass) in the middle and lower section of the river. Most tributaries are trout streams, although sedimentation may reduce the quality of the fisheries in some of these streams (TVA 1994).

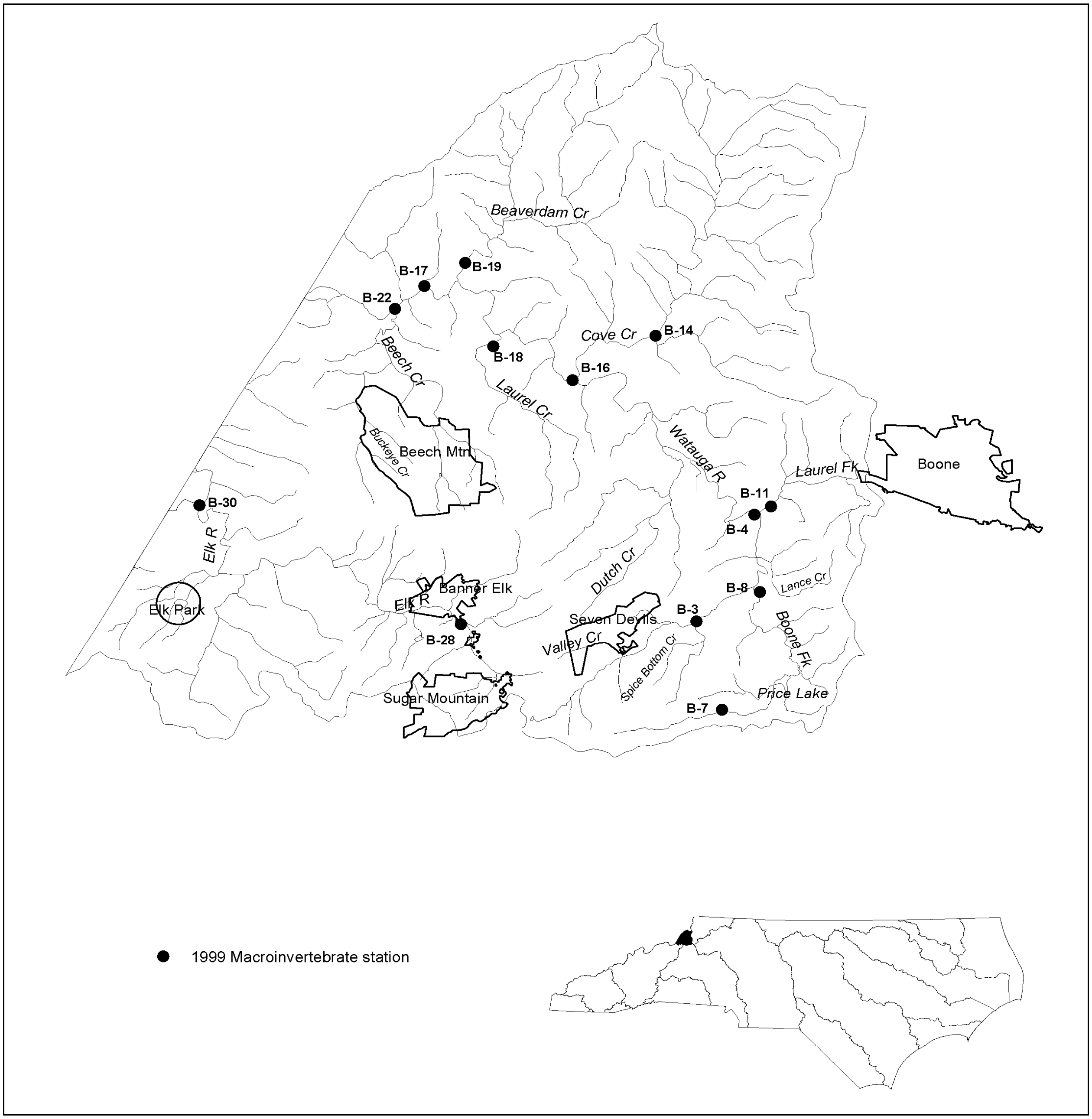

Figure 6. Sampling sites in Subbasin 01 in the Watauga River basin.

Portions of the basin are being rapidly developed for second homes and recreational activities, such as golf courses. Much of this development is focused near stream and river corridors, potentially affecting water quality through nonpoint source runoff and numerous small point source dischargers.

This basin contains over 25 NPDES permitted dischargers. The two largest facilities are the Banner Elk (0.6 MGD to the Elk River) and Sugar Mountain (0.5 MGD to Flattop Creek) wastewater treatment plants. The Sugar Mountain and Beech Mountain (0.4 MGD to Pond Creek) facilities are required by permit to monitor their effluent's toxicity.

Overview of water quality

Benthic macroinvertebrate data indicated stable water quality at most sites in the Watauga River basin (Table 2). A recent change in bioclassification was observed only for the headwater segment of the Watauga River near Foscoe, although there may have been a long-term decline for the lower segment of Boone Fork. The Foscoe site declined from Excellent to Good-Fair between 1994 and 1999. EPT taxa richness values also have been declining for the Watauga River at Shulls Mill and at Sugar Grove. However, the decreases were not large enough to result in changes in bioclassifications.

Overall, water quality in this basin is very good, with the majority of sites having a bioclassification of Good or Excellent based on macroinvertebrate data. The entire Watauga River was classified as High Quality Waters in 1990, although the most recent invertebrate collections indicate only Good-Fair water quality in the upper segment near Foscoe and Good water quality in the middle portion near Sugar Grove. Excellent ratings, however, were still assigned to sites at Shulls Mill and at Peoria. Boone Fork and tributaries, were classified as Outstanding Resource Waters in 1993. A benthos site on Boone Fork above Price Lake continued to be rated as Excellent.

The primary water quality problem in this basin is nonpoint source runoff, including inputs of sediment and nutrients. Many of the catchments in the Watauga River basin are intensively farmed, especially the Cove Creek, Beaverdam Creek and Laurel Creek watersheds. Heavy sediment loads may affect the quality of the fisheries, but such impacts may not be adequately evaluated by macroinvertebrate sampling.

Based upon the macroinvertebrate data, nonpoint source runoff appeared to have some impacts (Good or Good-Fair ratings) on some segments of the Watauga River, a part of the Elk River, Spice Bottom Creek, Cove Creek, Lance Creek, Laurel Fork, Dutch Creek, Laurel Creek, Beaverdam Creek, and Buckeye Creek.

Table 2. Waterbodies monitored in Subbasin 01 in the Watauga River basin for basinwide assessment, 1994 - 1999.

Map #	Stream	County	Location	1994	1999
B-3[1]	Watauga R	Watauga	SR 1580	Excellent	Good-Fair
B-4[1]	Watauga R	Watauga	NC 105	Excellent	Excellent
B-5[1]	Valley Cr	Watauga	NC 105	---	Not Rated
B-7[1]	Boone Fk	Watauga	SR 1561	Excellent	Excellent
B-8	Boone Fk	Watauga	off SR 1558	Good	Good
B-11[1]	Laurel Fk	Watauga	SR 1111	Good-Fair	Good-Fair
B-14	Cove Cr	Watauga	US 321	Good	Good
B-16[1]	Watauga R	Watauga	SR 1121	Good	Good
B-17[1]	Watauga R	Watauga	SR 1200	Excellent	Excellent
B-18	Laurel Cr	Watauga	off SR 1123	---	Good
B-19	Beaverdam Cr	Watauga	Old SR 1201	Good	Good
B-22	Beech Cr	Watauga	US 321	Excellent	Excellent
B-28	Elk R	Avery	off NC 184	Good	Good
B-30	Elk R	Avery	SR 1305	Excellent	Excellent

[1]Data are available prior to 1994, refer to Appendix B2.

River and Stream Assessment

Stream flow in the Watauga River basin for June and July 1999 was 66% and 106%, respectively of the long-term median flow for the Watauga River near Sugar Grove. However, there was a heavy rainfall just prior to benthos collections on July 11-12, 1999. Mean daily stream flow increased from 84 to 360 cfs over this two day period.

The higher flows did not affect the invertebrate sampling. Replicate samples were collected from the Watauga River near Foscoe under high flow conditions (July 12) and more normal flow conditions (July 13). Almost identical results were obtained from these two samples. Site ratings, however, might have been affected by scour prior to the 1999 collections. It was also expected that the effects of nonpoint source runoff would be more evident after a period of high flow. Abundant macroinvertebrate populations were often associated with a refuge from scour such as a larger boulder substrate, moss, or riverweed that grew in some boulder and bedrock areas.

Many of the sites that were sampled in this subbasin have roads that run parallel to the stream, leading to frequent breaks in the riparian zone. Some of the streams in this subbasin also were located in areas of agricultural or residential land use, often with a narrow riparian buffer zone.

Watauga River Watershed

Four sites were sampled on the mainstem of the Watauga River: Foscoe (SR 1580), Shulls Mill (NC 105), Sugar Grove (SR 1121), and Peoria (SR 1200) Stream widths at these sites were, 10, 17, 20, and 25 m, respectively. Habitat problems that were common to most sites included:

- embedded substrate,
- infrequent pools,
- narrow riparian zones, and
- frequent breaks in the riparian zone.

An important component of the river habitat is the abundance of "riverweed" in riffle areas, which may act as a refuge from high flow and scour. This plant was absent in the river at Foscoe, but abundant in other areas with boulder or bedrock substrates. Greatest growth of riverweed was observed in the river at Shulls Mill and Peoria. Both of these sites received an Excellent bioclassification. Most of the riverweed in the middle portion of the river is *Podostemum*, but a second (unknown) species was observed at the Peoria site. Abundant periphyton growths were observed at Foscoe, suggesting some enrichment at this site. All sites had pH values greater than 7.0 during the 1999 monitoring; values of 7.5-8.1 were recorded in the middle and lower segments of the river. However, monthly data from the ambient locations did not indicate any long-term increase in pH.

Conductivity levels can often be used as a surrogate for general disturbance, as long as comparisons are made within equivalent geologic areas. Conductivity data collected at the Shulls Mill and Sugar Grove sites over the last 10 years indicated a greater mean at the downstream site than at the upstream site and an increase over time (Figure 7). These increases, however, were not statistically significant (refer to the Ambient Monitoring System Summary).

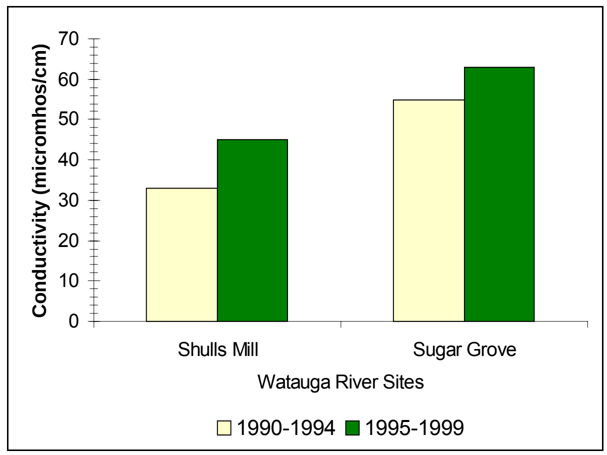

Figure 7. Conductivity at two sites on the Watauga River.

Watauga River, SR 1580

This site near Foscoe was rated Good in 1985, although it has subsequently been rated Excellent in 1988 and 1994 (Table 3).

Table 3. Flow and bioclassifications for the Watauga River at SR 1580, Watauga County.

Year	Flow	Rating
1985	Low	Good
1988	Low	Excellent
1994	High	Excellent
1999	High	Good-Fair

In 1999, the bioclassification declined to Good-Fair with much lower EPT taxa richness and abundance relative to earlier years (Figure 8).

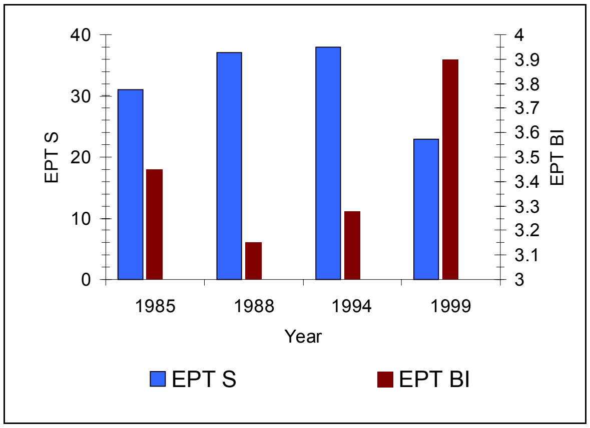

Figure 8. **EPT (EPT S) taxa richness and biotic index (EPT BI) for the Watauga River, SR 1580, Watauga County.**

This site was dominated in 1999 by relatively tolerant EPT taxa such as *Symphitopsyche sparna*, *Baetis intercalaris*, and *Acentrella*. Many taxa showed low abundance in 1999, especially Heptageniidae, Plecoptera, and stone-cased Trichoptera. The latter two groups are intolerant, suggesting a decline in water quality.

The SR 1580 site is located below a cluster of small dischargers. Upstream land use includes residential and agricultural areas. Nonpoint source runoff was the most likely cause of the declining bioclassification at this site, although there was little buildup of sediment in this high gradient section of the river. The lack of riverweed at the Foscoe site may make this site more susceptible to scour during high flow events.

Ambient water quality data were collected further downstream at the Shulls Mill site. Few water chemistry problems could be identified, although there seemed to be a trend of increasing suspended solids, especially at high flows. Conductivity has shown a slight, but not statistically significant increase over the last five years. There was no relationship between flow and conductivity, indicating that point source dischargers could not be responsible for the elevated values.

Watauga River, NC 105

There have been six summer collections at the Shulls Mill site since 1985, all resulting in Excellent bioclassifications (Table 4).

Table 4 **Flow and bioclassifications for the Watauga River at NC 105, Watauga County.**

Year	Flow	Rating
1985	Low	Excellent
1987	Low	Excellent
1988	Low	Excellent
1989	Normal	Excellent
1994	High	Excellent
1999	High	Excellent

The 1994 and 1999 benthos collections had the lowest total taxa EPT taxa richness and abundance values of any sampling periods (Figures 9 and 10).

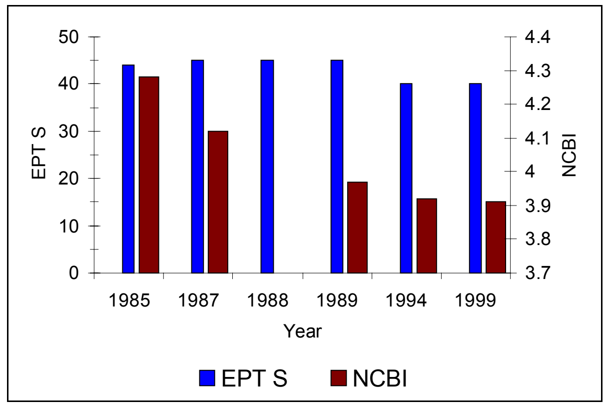

Figure 9. **EPT (EPT S) taxa richness and biotic index (NCBI) for the Watauga River, NC 105, Watauga County.**

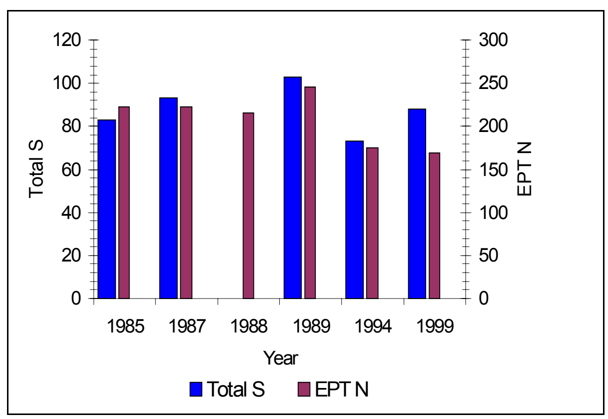

Figure 10. **Total (Total S) taxa richness and EPT abundance (EPT N) for the Watauga River, NC 105, Watauga County.**

Several intolerant species, including *Drunella allegheniensis* and *Neophylax,* showed a sharp decline in abundance in the recent collections. The diversity of stoneflies at this site decreased from 7 and 8 taxa during 1985 - 1994 to only 3 taxa in 1999. High flows for the last two collections may be partially responsible for these changes (Table 4), but this portion of the river should be closely monitored for any other evidence of a decline in water quality.

Watauga River, SR 1121

Most collections from this site near Sugar Grove have produced a Good rating, although an Excellent rating was assigned in 1990 (Table 5). Field notes for this site frequently indicated heavy periphyton growths (especially at low flow), suggesting some enrichment. Field notes also recorded large amounts of sediment, with sand and gravel usually comprising 50% of the substrate. Finer sediments often settle out near the banks.

Table 5. Flow and bioclassifications for the Watauga River, SR 1121, Watauga County.

Year	Flow	Median Flow[1]	Rating
1983	Low	54	Good
1984	High-Normal	110	Good
1985	Normal	81	Good
1986	Low	34	Good
1988	Low	37	Good
1990	Low	59	Excellent
1994	High	151	Good
1999	High-Normal	108	Good

[1]Median flow (cfs) three weeks prior to sampling.

The abundance of tolerant Chironomidae, Oligochaeta, and Mollusca under low flow conditions (1983 - 1990) suggested some water quality problems, but these groups have been much less abundant under the high flows observed in 1994 and 1999. The general scarcity of Plecoptera in all years also suggested water quality problems, but the reduction in EPT taxa richness and abundance under high flow conditions also indicated habitat problems. The EPT taxa richness value for 1999 (38) was the lowest since invertebrate collections were initiated in 1983 (Figure 11).

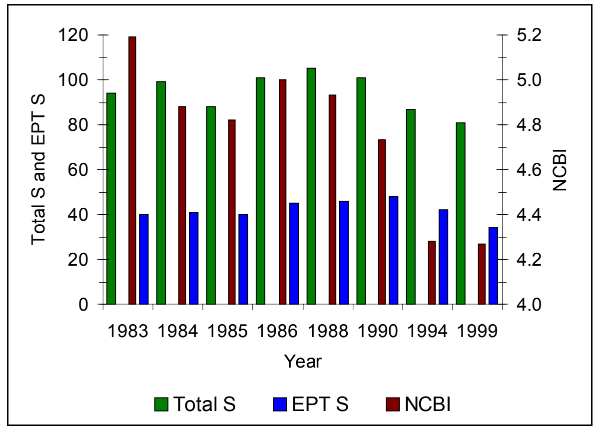

Figure 11. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Watauga River, SR 1121, Watauga County.

Watauga River, SR 1200

This site near Peoria received an Excellent rating in 1994 and 1999, indicating some recovery from the problems observed at the Sugar Grove site. Part of this improvement may be related to the better habitat at the Peoria site. This site had the highest EPT taxa richness (50) in the Watauga River basin in 1999.

Watauga River Tributaries

Ten tributary locations were sampled for benthic macroinvertebrates in 1999, and nine of these sites had previously been sampled.

Valley Creek, NC 105

Valley Creek is a very small stream with an average width of only three meters. Mountain streams of this size should not be rated unless in undisturbed watersheds. The prior rating of this stream (Good-Fair in 1990) was an incorrect evaluation of water quality.

Valley Creek drains the Seven Devil's area and receives discharges from two small wastewater treatment plants. These discharges may account for the elevated conductivity (82 µmhos/cm) recorded at Valley Creek during our 1999 invertebrate collections. This is a high gradient stream, and sediment inputs may be flushed through the system without being deposited in the stream bed. Good boulder/rubble habitat was recorded here, with little accumulation of sand and silt.

The fauna was dominated by intolerant taxa, especially *Epeorus dispar* and *Symphitopsyche macleodi*. EPT taxa richness indicated no water quality problems for this stream in 1999 (23), and

EPT taxa richness was similar to that recorded in March 1990 after seasonal correction (26).

Boone Fork, SR 1561
Boone Fork is a relatively small stream (six meters wide) and many of the benthic organisms collected at this site are limited to small mountain streams. The headwater portion of Boone Fork seemed to have the best water quality in the basin, and the invertebrate collections supported its Excellent rating and ORW designation. This site had the lowest conductivity (12 µmhos/cm) and the lowest biotic index (2.6) of any stream in the basin.

Boone Fork, off SR 1558
This portion of Boone Fork, below Price Lake, is about 12 m wide with a rocky substrate. It was included in the ORW designation based on an Excellent rating assigned in March 1990 (Table 6). But this segment currently has much lower water quality than the segment upstream of Price Lake.

Table 6. Flow and bioclassifications for Boone Fork, off SR 1558 (below Price Lake), Watauga County.

Year	Flow	Rating
1990	Normal	Excellent
1994	High	Good
1999	High-Normal	Good

EPT S (corrected for any changes in taxonomy) were very similar in 1994 (31) and 1999 (30), producing a Good bioclassification for both years (Figure 12). EPT N values, however, were less than the values expected for a Good rating: 101 - 119 for this site *vs*. an expected range of 125 – 201.

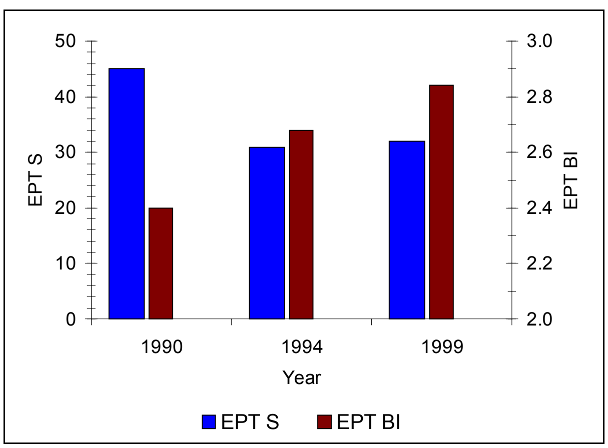

Figure 12. EPT (EPT S) taxa richness and biotic index (EPT BI) for Boone Fork, off SR 1561 (below Price Lake), Watauga County.

It is possible that Price Lake has some negative effect on the flow and temperature regime for the lower reaches of Boone Fork. Habitat analysis did not indicate any significant problems. Relative to the site at SR 1561, this site was visibly more turbid and had higher conductivity (21 *vs*. 12 µmhos/cm), pH (7.3 *vs*. 6.7), and temperature (17 *vs*. 13^{o}C). Stone-cased caddisflies and Plecoptera were less abundant than expected in this part of Boone Fork.

Laurel Fork, SR 1111
Laurel Fork is a medium-sized stream (eight meters wide) that drains portions of Boone. There are four small dischargers upstream of this point, which may account for the elevated conductivity (80 µmhos/cm) at the time of the invertebrate collections. Although the substrate is mainly boulder and rubble, the rocks were severely embedded and pools were infrequent.

This site was rated Good-Fair in 1994 and 1999, based on EPT taxa richness values of 24 and 27. No stoneflies were abundant at this site in either year. The benthic fauna was dominated by the tolerant caddisfly, *Symphitopsyche sparna*.

Cove Creek, NC 321
Cove Creek is a medium-sized stream (eight meters wide) that drains an agricultural and residential area. The NCSU Water Quality Group has completed a restoration project on about 0.1 miles of badly eroding stream bank (personal communication, Will Harman, NCSU). They have also noted increasing development in the upper part of the Cove Creek watershed.

Corrected EPT taxa richness has been very stable at this site (30 - 33), producing a Good rating in 1994 and 1999. Erosion in this catchment has resulted in an embedded substrate, infrequent riffles, and few pools. Abundant growths of riverweed are found only in a few high-current riffles. No stonefly taxa were abundant in the 1999 collection, and stone-cased caddisflies were rare. However, one intolerant mayfly (*Potamanthus distinctus*) was abundant in this stream.

Laurel Creek, off SR 1123
Laurel Creek is a small stream (six meters wide) that drains an area of agricultural and residential land use. This stream had an elevated conductivity at the time of the macroinvertebrate sampling (85 µmhos/cm), although there are no permitted dischargers in this catchment. The overall habitat was good, but the substrate was embedded and pools were infrequent. Laurel

Creek was sampled for the first time in 1999, with a bioclassification of Good.

Beaverdam Creek, SR 1201
This medium-sized stream (10 m wide) was characterized by heavily embedded boulder substrate. Based on EPT taxa richness, a Good rating was recorded in 1994 and 1999. This was the only site where *Barbaetis cestus* has been collected in the basin. Although this species is uncommon, it does not seem to be highly intolerant.

Beech Creek, US 321
Beech Creek had excellent habitat and supports a good trout fishery. Conductivity was 31 µmhos/cm at the time of the invertebrate collection. This site has been rated as Excellent in 1994 and 1999, and did not seem to be affected by residential/ recreational development in the headwaters. This part of Beech Creek is the only known North Carolina locality for the intolerant caddisfly *Ceratopsyche* (= *Symphitopsyche*) *walkeri*. This species was abundant in the high-current riffles.

Elk River Watershed

Both monitoring sites on the Elk River had heavy periphyton growths, suggesting some nutrient enrichment. All parts of this river appeared "filled in", with long riffle/runs and few pools. The substrate was heavily embedded at both sites (about 40%), and there was often a narrow riparian zone. The high flows observed in Watauga County in 1999 did not occur at these sites in Avery County, presumably due to lower amounts of rainfall in Avery County.

Elk River, off NC 184
This site, downstream of Banner Elk, was only about six meters wide, but still supported a very high diversity of benthic macroinvertebrates. Although a Good rating was assigned in 1994 and 1999 (Table 7), some between-year improvement was suggested by a large increase in EPT taxa richness and abundance (Figure 13).

Table 7. Flow and bioclassifications for Elk River, off NC 184, Avery County.

Year	Flow	Rating
1994	High	Good
1999	Normal	Good

Specific EPT taxa that increased in abundance included *Leucrocuta*, *Baetis flavistriga*, *Serratella deficiens*, *Serratella serrata*, *Dolophilodes*, *Chimarra*, and *Rhyacophila fuscula*. Some water quality problems were indicated during both years by the scarcity of long-lived perlid stoneflies.

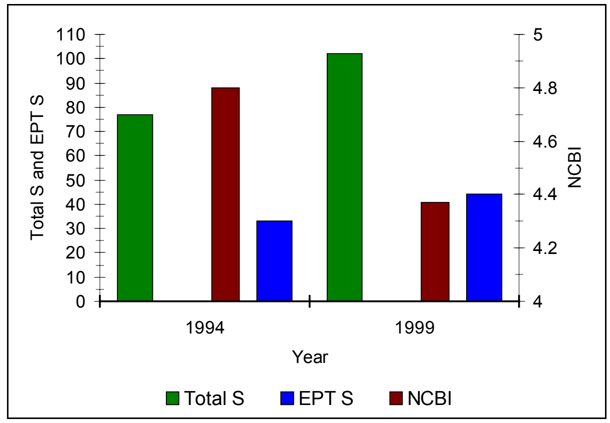

Figure 13. Total (Total S) and EPT (EPT S) taxa richness and biotic index (NCBI) for the Elk River, off NC 184, Avery County.

Very high total taxa richness was recorded for this site in 1999 (102) (Figure 12), partially due to very high taxa richness for the Chironomidae (33). This pattern may be associated with lower flow (and lower scour) in 1999 (Table 7), which allowed a diverse community of periphyton grazers to develop in this portion of the river.

Elk River, SR 1305
This portion of the Elk River was 13 m wide and had small patches of riverweed. It received an Excellent bioclassification in 1994 and 1999, indicating some recovery from upstream problems. Although some intolerant species were present, facultative Hydropsychidae and Baetidae dominated the community.

Special Studies
During April 1999, TVA biologists collected information on fish, macroinvertebrates, and habitat characteristics at three sites in the Watauga basin (unpublished data) (Table 8). The macroinvertebrate data was limited to the number of EPT families with a maximum score of about 25 families/site. The habitat assessment score had a maximum value of 52.

Overall, results were similar to those from the Division studies. Habitat problems were observed at Cove Creek and the upper Watauga River, with a reduction in the numbers of species of fish and EPT taxa richness. Substantial recovery was observed in the lower Watauga River.

Table 8. Biological and habitat data collected by the Tennessee Valley Authority from the Watauga River basin, Watauga County, April 20-21, 1999. Note: EPT ratings are not equivalent to Division ratings.

Stream	Location	No. of EPT Families	EPT Rating	No. of Fish Species	No. of Fish	TVA IBI	Habitat Score
Cove Cr	SR 1121	15	Good	12	398	38	31
Watauga R	SR 1149	16	Good	12	506	38	35
Watauga R	SR 1200	20	Excellent	15	728	48	50

AMBIENT MONITORING SYSTEM

The Division collects ambient water quality information from approximately 421 active monitoring stations statewide. In the Watauga River basin there are three stations, all located on the mainstem of the Watauga River (Table 9 and Figure 14).

Regional flow patterns generally showed greater than normal flows beginning in 1994 to about 1998 (Figure 15). Beginning in 1998, yearly and monthly median flows displayed decreases. The graph depicting flow in the Hiwassee River does not include data for the water year 1998 - 1999, but the yearly median flow followed the patterns for the yearly median for the Watauga and Little Tennessee rivers.

The Watauga River, at the most upstream site at Shulls Mill, is approximately 10 m wide and has a substrate dominated by large boulders and rubble. The gradient is relatively high at this monitoring location, resulting in very little deposition of sand. At the most downstream site at Sugar Grove, the river is approximately 15 m wide and has a substrate with a greater proportion of sand. There is little shading at this monitoring location, which may account for higher water temperatures relative to the upstream monitoring location at Shulls Mill. Water quality conditions at the Sugar Grove location may be affected by urban areas of Boone.

Regional flow patterns generally showed greater than normal flows beginning in 1994 to about 1998 (Figure 14). Beginning in 1998, yearly and monthly median flows began to decrease. The graph depicting flow in the Hiwassee River does not include data for the water year 1998-1999, but the yearly median flow follows the same patterns for the Watauga River and Little Tennessee River.

Table 9. Ambient monitoring system stations within the Watauga River basin.

Station Code	Station	County	Class
L2000000	Watauga R at NC 105 - Shulls Mill	Watauga	B Tr, HQW
L2350000	Watauga R at SR 1114 - Valle Crucis	Watauga	B Tr, HQW
L4700000	Watauga R at SR 1121 - Sugar Grove	Watauga	B Tr, HQW

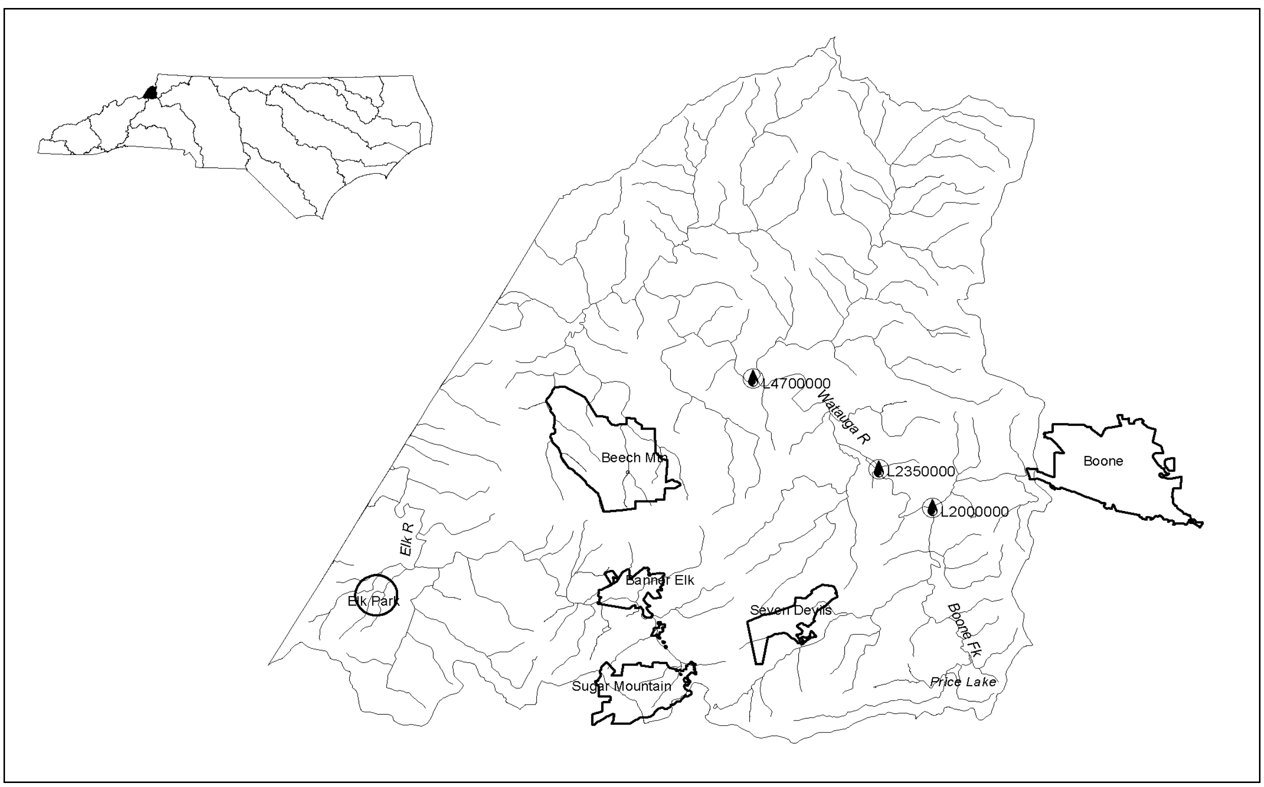

Figure 14. Ambient monitoring system stations in the Watauga River basin.

Few temporal patterns were evident among the parameters monitored (Figures 16 – 26). Patterns were limited to conductivity, pH, and hardness. Conductivity increased at the Shulls Mill and Valle Crucis sites with a concomitant decrease in pH (Figures 16 and 17). These patterns were corrected for flow but there was not enough data available to establish statistical significance. Hardness concentrations showed a slight increase since about 1997 (Figure 20).

The previous basinwide assessment report mentioned decreases in conductivity and nitrite+nitrate nitrogen (NCDEHNR 1996). These patterns were discerned using box and whisker plots of the data for all three stations. However, line graphs of these data for each station did not confirm these patterns (Figure 16 and 25).

Fecal coliform bacteria data are provided in Table 10 and Figure 19. This table compares the geometric mean and proportion of samples greater than 200 colonies/100 ml for three time periods. Geometric means of fecal coliform bacteria showed a substantial decrease over time for the station near Sugar Grove. The geometric mean for the Shulls Mill site has remained relatively stable (17 - 28 colonies/100 ml).

Wastewater treatment plant upgrades at The Ponds (NC0050610) and Mill Ridge (NC0030473) in 1996 and 1992, respectively, including shifts from tablet chlorination to UV disinfection, could possibly have influenced downward trends in fecal coliform concentrations. Both facilities are upstream of the Sugar Creek Grove and Shulls Mills sites, yet the proximal Shulls Mills reduction was not as evident as the distal Sugar Grove. No other significant land-use changes are known in the area that may have influenced this possible trend. Too few data have been collected from the Valle Crucis site to discern any temporal patterns.

Fecal coliform bacteria exceeded the water quality standard 20 times during the recent monitoring cycle. These excesses ranged from 220 to 2,000 colonies/100 ml and did not necessarily result from recent precipitation because many occurred during periods of low flow. Two of the three stations had exceedances on 09/13/1994, 06/20/1995, 07/16/1996, 06/15, 09/17, and 12/09/1998.

Few measured parameters exceeded the reference levels representing a water quality standard (Tables 11 - 13). Total suspended solids (TSS) exceeded the standard (10 mg/l) for trout waters at all three monitoring stations. The proportion of samples from a site which exceeded the standard ranged from 9 to 14%.

Many of these excesses were observed on the same day (06/20/1995, 09/11/1997, and 06/15/1998) for all three stations. This might have been related to higher than normal flows resulting from recent precipitation. However the correlations for TSS among stations was low (r = 0.01 to 0.14). The greatest TSS concentration (95 mg/l at the station near Valle Crucis) occurred during lower than normal flows while the TSS concentrations at the other two stations was 1.0 mg/l.

Turbidity exceeded the standard (10 NTU) four times (6.9%) and only at Sugar Grove (Table 13). Three of these excesses occurred during periods of higher than normal flows.

Excesses could also be seen for chromium, copper, and iron. Only iron exceeded the standard for greater than 10% of the samples (14%) at Sugar Grove. Iron, however, is a common element in soils. The ecological significance of copper and iron values can only be interpreted with additional ecotoxicity testing.

Table 10. Summary of fecal coliform bacteria collections from the Watauga River basin, 1970 - 1999[1].

Site	First Sample	Last Sample	N[2]	Geometric Mean	N > 200	% > 200
Watauga R - Shulls Mill	05/05/1970	06/29/1989	23	27.8	1	4.3
	09/12/1989	08/22/1994	22	17.0	0	0.0
	09/13/1994	**08/24/1999**	**56**	**27.4**	**4**	**7.1**
Watauga R - Valle Crucis	03/14/1993	08/22/1994	11	39.4	1	9.1
	09/13/1994	**08/24/1999**	**53**	**28.2**	**7**	**13.2**
Watauga R - Sugar Grove	06/12/1975	06/29/1989	118	135.0	45	38.1
	09/12/1989	08/22/1994	22	53.1	4	18.2
	09/13/1994	**08/24/1999**	**55**	**44.4**	**9**	**16.4**

[1] Row in bold face represents the summary for the current basin assessment period (09/01/1994 to 08/31/1999).
[2] N = Number of samples; N > 200 = number of samples > 200 colonies/100ml; % > 200 = proportion (%) of samples > 200 colonies/100 ml.

Table 11. **Summary of water quality parameters collected from the Watauga River near Shulls Mill (Station L2000000; Class B Tr HQW) during the period 09/01/1994 to 08/31/1999.**

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	49	.	.	.	.	0	24	4	8	11	18	22
Conductivity	50	.	.	.	.	26	84	32	35	43	55	63
Dissolved Oxygen	50	.	6	0	.	7.2	13.0	8.5	9.0	10.7	11.6	12.4
pH (s.u.)	49	.	6-9	4	8.2	5.4	8.2	6.1	6.6	7.1	7.3	7.6
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	57	.	.	.	10.5	1	62	1	1	2	5	12
Hardness	58	0	.	.	.	10	59	12	14	17	24	32
Chloride	0	0	.	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	57	13	10	0	.	1.0	8.4	1.0	1.0	1.4	2.3	3.5
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	56	27	200	4	7.1	9	2000	10	10	10	71	149
Nutrients												
NH_3 as N	58	23	.	.	.	0.01	0.14	0.01	0.01	0.02	0.04	0.05
TKN as N	57	3	.	.	.	0.1	0.4	0.1	0.1	0.1	0.2	0.2
NO_2+NO_3 as N	58	0	.	.	.	0.16	0.66	0.22	0.27	0.33	0.39	0.48
Total Phosphorus	58	14	.	.	.	0.01	0.11	0.01	0.01	0.02	0.03	0.03
Metals (total)												
Arsenic	57	57	50	0	.	0	10	10	10	10	10	10
Cadmium	57	57	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	57	56	50	1	1.8	25	74	25	25	25	25	25
Copper	57	25	7	5	8.8	2	14	2.0	2.0	3.0	5.0	7.0
Iron	57	0	1000	2	3.5	59	2300	112	158	230	360	608
Lead	57	57	25	0	.	10	10	10	10	10	10	10
Manganese	3	1	.	.	.	10	17	.	10	11	16	.
Nickel	57	57	88	0	.	10	10	10	10	10	10	10
Aluminum	57	8	.	.	.	50	1500	50	68	99	183	346
Mercury	56	56	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 12. Summary of water quality parameters collected from the Watauga River near Valle Crucis (Station L2350000; Class B Tr HQW) during the period 09/01/1994 to 08/31/1999.

								Percentiles				
Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	10	25	50	75	90
Field												
Temperature (^oC)	51	.	.	.	.	0	26	4	7	12	20	22
Conductivity	51	.	.	.	.	32	74	37	44	49	56	62
Dissolved Oxygen	51	.	6	0	.	7.2	13.8	8.8	9.5	10.8	11.8	12.3
pH (s.u.)	50	.	6-9	0	.	6.1	7.9	6.5	7.0	7.2	7.5	7.6
Other												
Total Residue	0	0	.	.	.	.	.	.	.	.	.	.
Total Sus. Solids	55	6	.	.	.	1	95	1	1	2	4	7
Hardness	56	0	.	.	.	10	180	14	16	20	26	36
Chloride	0	0	.	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	56	11	10	0	.	1.0	9.1	1.0	1.0	1.3	2.1	3.3
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	53	26	200	7	13.2	10	1600	10	10	10	63	300
Nutrients												
NH_3 as N	55	19	.	.	.	0.01	0.18	0.01	0.01	0.02	0.05	0.07
TKN as N	55	0	.	.	.	0.1	0.6	0.1	0.1	0.2	0.2	0.4
NO_2+NO_3 as N	55	0	.	.	.	0.14	0.69	0.27	0.30	0.36	0.42	0.51
Total Phosphorus	55	20	.	.	.	0.01	0.11	0.01	0.01	0.01	0.02	0.03
Metals (total)												
Arsenic	55	55	50	0	.	10	10	10	10	10	10	10
Cadmium	55	55	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	55	55	50	0	.	25	25	25	25	25	25	25
Copper	55	17	7	5	9.1	2	17	2.0	2.0	3.0	4.8	7.0
Iron	55	0	1000	3	5.5	64	1900	120	130	190	338	460
Lead	55	52	25	2	.	10	39	10	10	10	10	10
Manganese	3	0	.	.	.	11	14	.	11	11	13	.
Nickel	55	55	88	0	.	10	10	10	10	10	10	10
Aluminum	55	7	.	.	.	50	910	50	62	97	148	230
Mercury	55	55	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

Table 13. Summary of water quality parameters collected from the Watauga River near Sugar Grove (Station L4700000; Class B Tr HQW) during the period 9/1/1994 to 8/31/1999.

Parameter	N	N < RL	Ref.	N > Ref.	% > Ref .	Min.	Max	Percentiles 10	25	50	75	90
Field												
Temperature (^oC)	52	.	.	.	.	0	26	5	8	12	21	23
Conductivity	52	.	.	.	.	41	87	50	55	63	74	78
Dissolved Oxygen	52	.	6	0	.	7.0	12.8	8.8	9.5	11.0	11.6	12.6
pH (s.u.)	51	.	6-9	0	.	6.4	8.4	6.5	7.1	7.4	7.8	8.0
Other												
Total Residue	1	0	.	.	.	83	83	.	.	83	.	.
Total Sus. Solids	56	8	.	.	.	1	50	1	1	3	6	17
Hardness	58	0	.	.	.	14	78	18	21	27	32	37
Chloride	0	0	.	.	.	.	.	.	.	.	.	.
Turbidity (NTU)	58	14	10	4	6.9	1.0	18.0	1.0	1.0	1.7	3.6	9.7
Bacteria												
Total coliform	0	0	.	.	.	.	.	.	.	.	.	.
Fecal coliform	55	15	200	9	16.4	10	720	10	10	36	133	320
Nutrients												
NH_3 as N	58	24	.	.	.	0.01	0.20	0.01	0.01	0.02	0.04	0.07
TKN as N	58	1	.	.	.	0.1	0.4	0.1	0.1	0.2	0.2	0.3
NO_2+NO_3 as N	58	0	.	.	.	0.24	1.50	0.38	0.46	0.63	0.85	1.07
Total Phosphorus	58	11	.	.	.	0.01	0.12	0.01	0.01	0.02	0.03	0.06
Metals (total)												
Arsenic	57	57	50	0	.	10	10	10	10	10	10	10
Cadmium	57	57	0.4	N/A	.	2	2	2	2	2	2	2
Chromium	57	56	50	0	.	25	29	25	25	25	25	25
Copper	57	18	7	5	8.8	2	18	2.0	2.0	3.0	5.0	7.0
Iron	57	0	1000	8	14.0	65	2200	122	170	250	370	1200
Lead	57	57	25	0	.	10	10	10	10	10	10	10
Manganese	1	0	.	.	.	12	12	.	.	12	.	.
Nickel	57	57	88	0	.	10	10	10	10	10	10	10
Aluminum	57	3	.	.	.	50	1500	57	91	140	210	718
Mercury	57	57	0.012	N/A	.	0.2	0.2	0.2	0.2	0.2	0.2	0.2

Abbreviations:

N	Total number of samples.
N < RL	Number of samples less than the Division analytical reporting level (RL).
Ref	Water quality reference (standard or action level); see NC Administrative Code 15A NCAC 2B .0200.
N > Ref	Number of samples greater than (or less than) the reference.
% > Ref	Proportion (%) of samples greater than the reference.
Min	Minimum.
Max	Maximum.
N/A	Not applicable because all samples were less than the reporting level.

Units of Measurement

As noted. Conductivity = µmhos/cm; bacteria = no. colonies/100 ml; metals = µg/l; all others = mg/l.

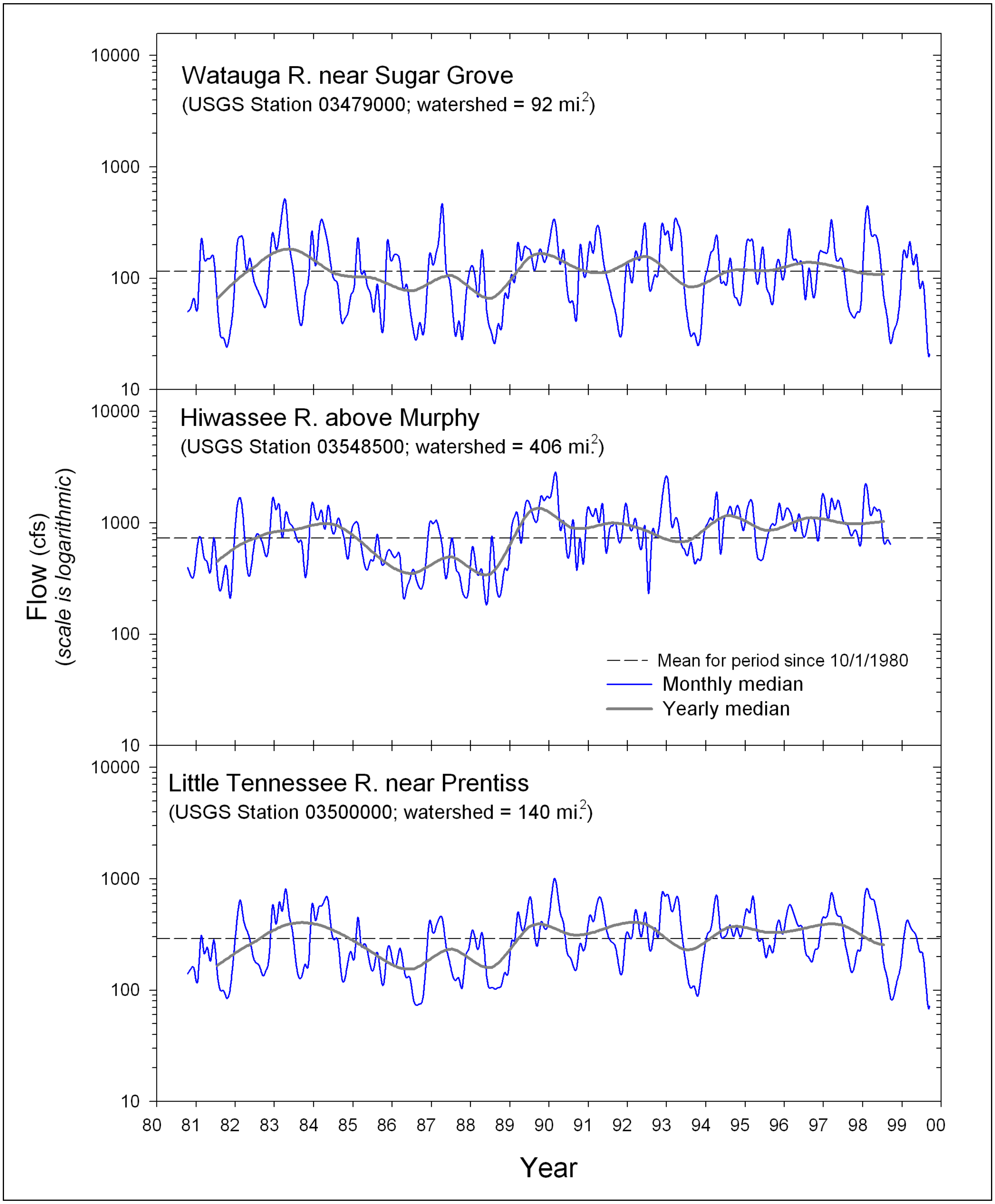

Figure 15. **Regional patterns for river flow, 1980 - 1999. (Data from US Geological Survey: http://nc.water.usgs.gov/).**

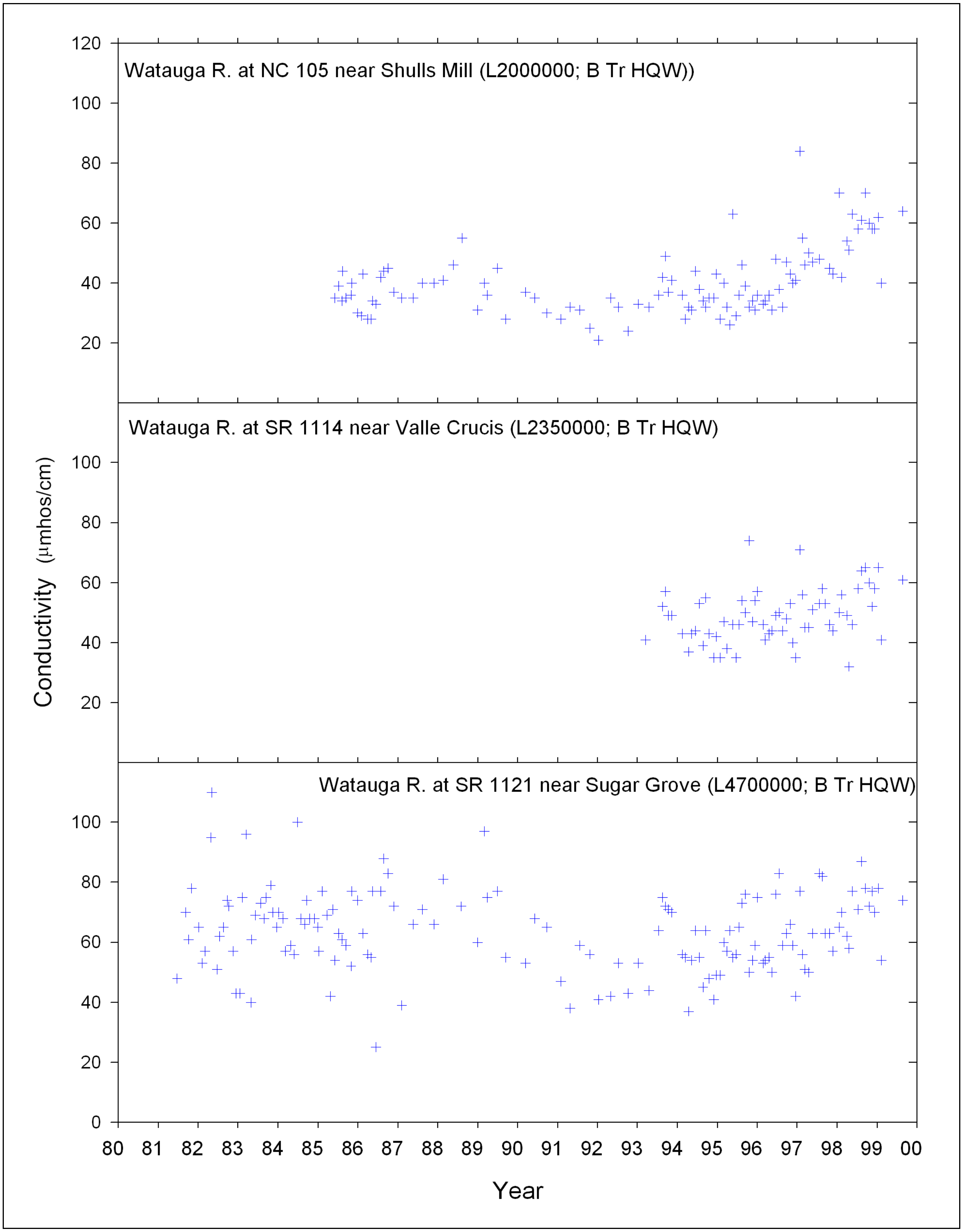

Figure 16. Temporal patterns for conductivity in the Watauga River basin, 1980 - 1999.

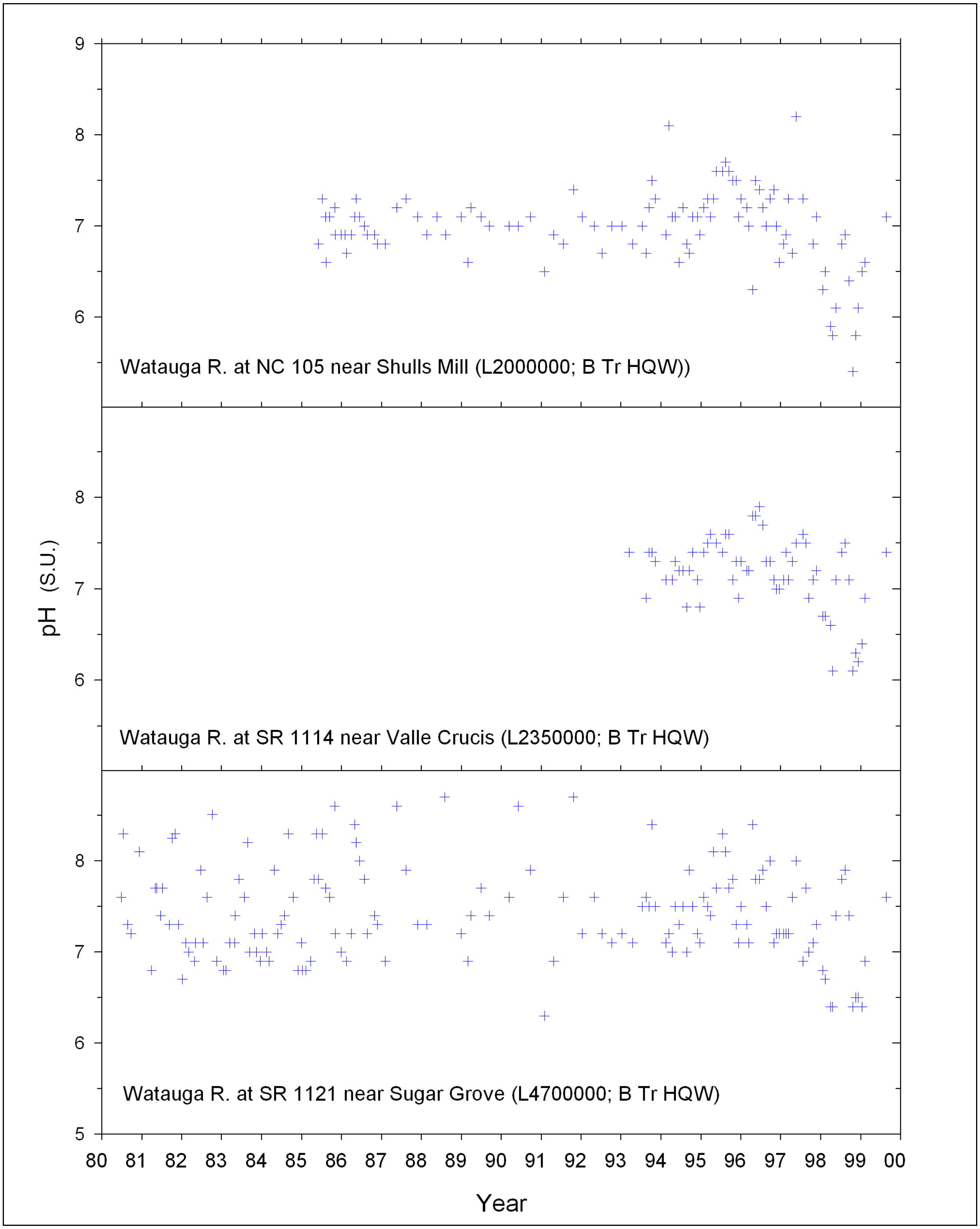

Figure 17. Temporal patterns for pH in the Watauga River basin, 1980 - 1999.

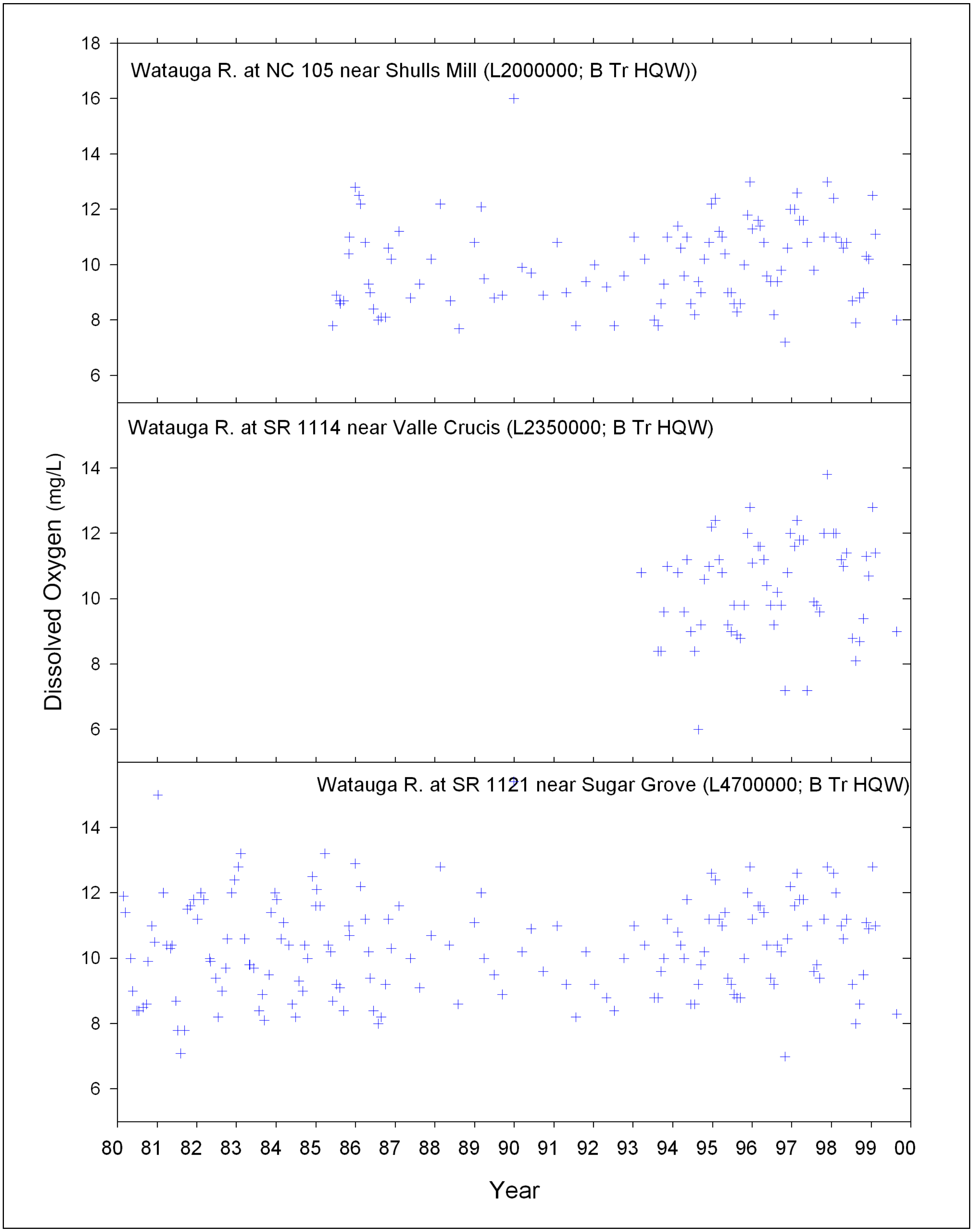

Figure 18. Temporal patterns for dissolved oxygen in the Watauga River basin, 1980 - 1999.

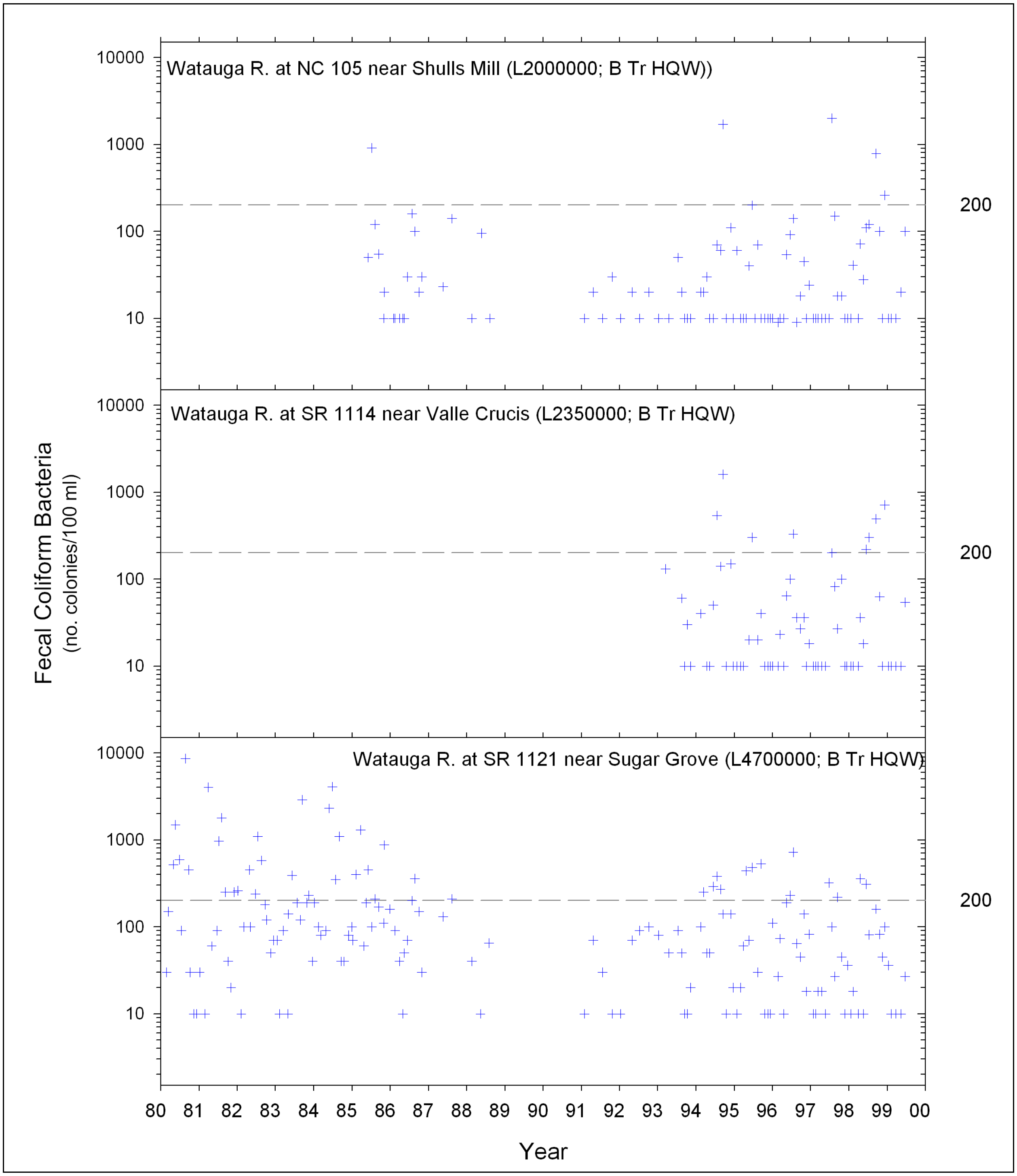

Figure 19. **Temporal patterns for fecal coliform bacteria in the Watauga River basin, 1980 - 1999. Dashed line represents a standard of 200 colonies/100 ml.**

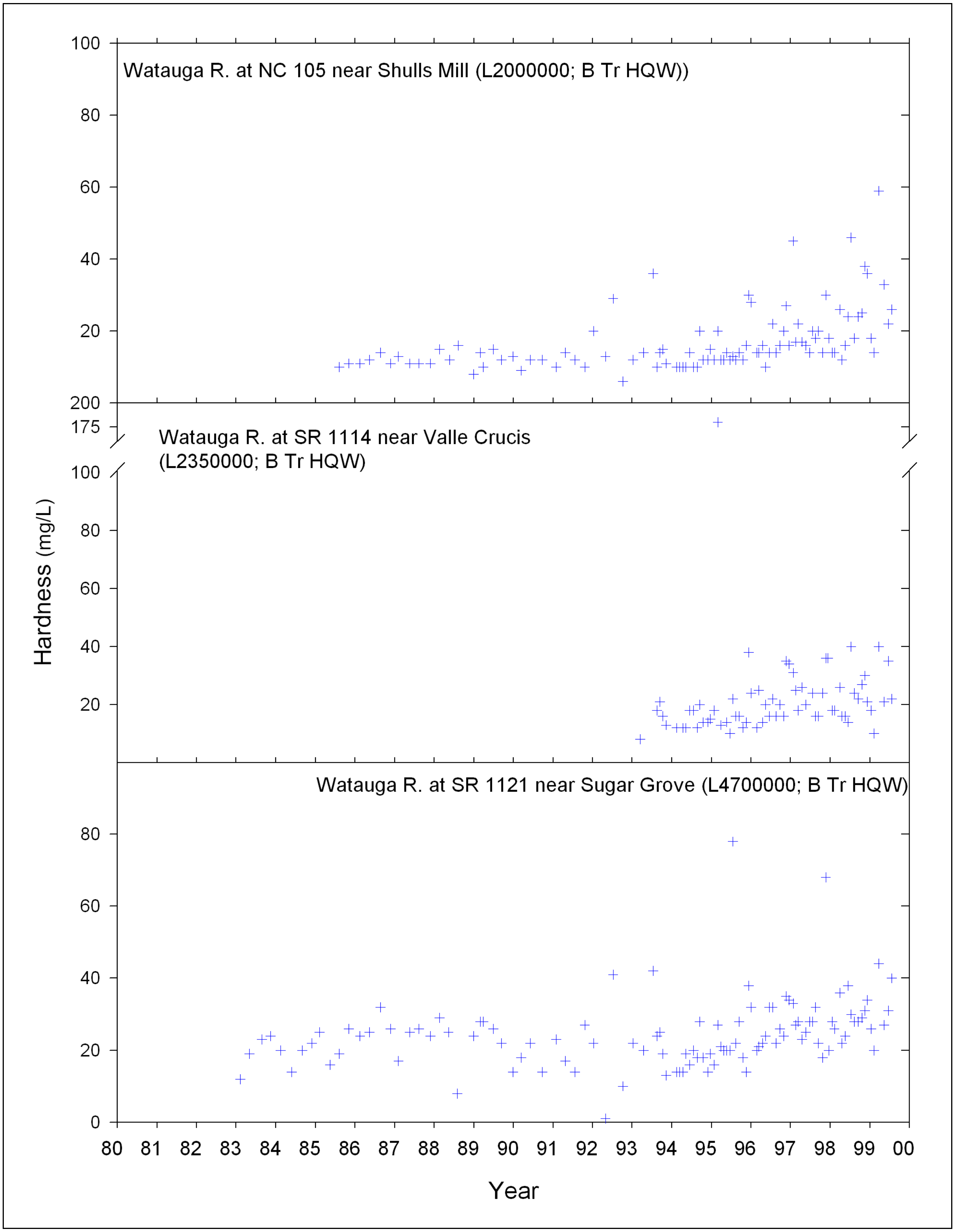

Figure 20. Temporal patterns for hardness in the Watauga River basin, 1980 - 1999.

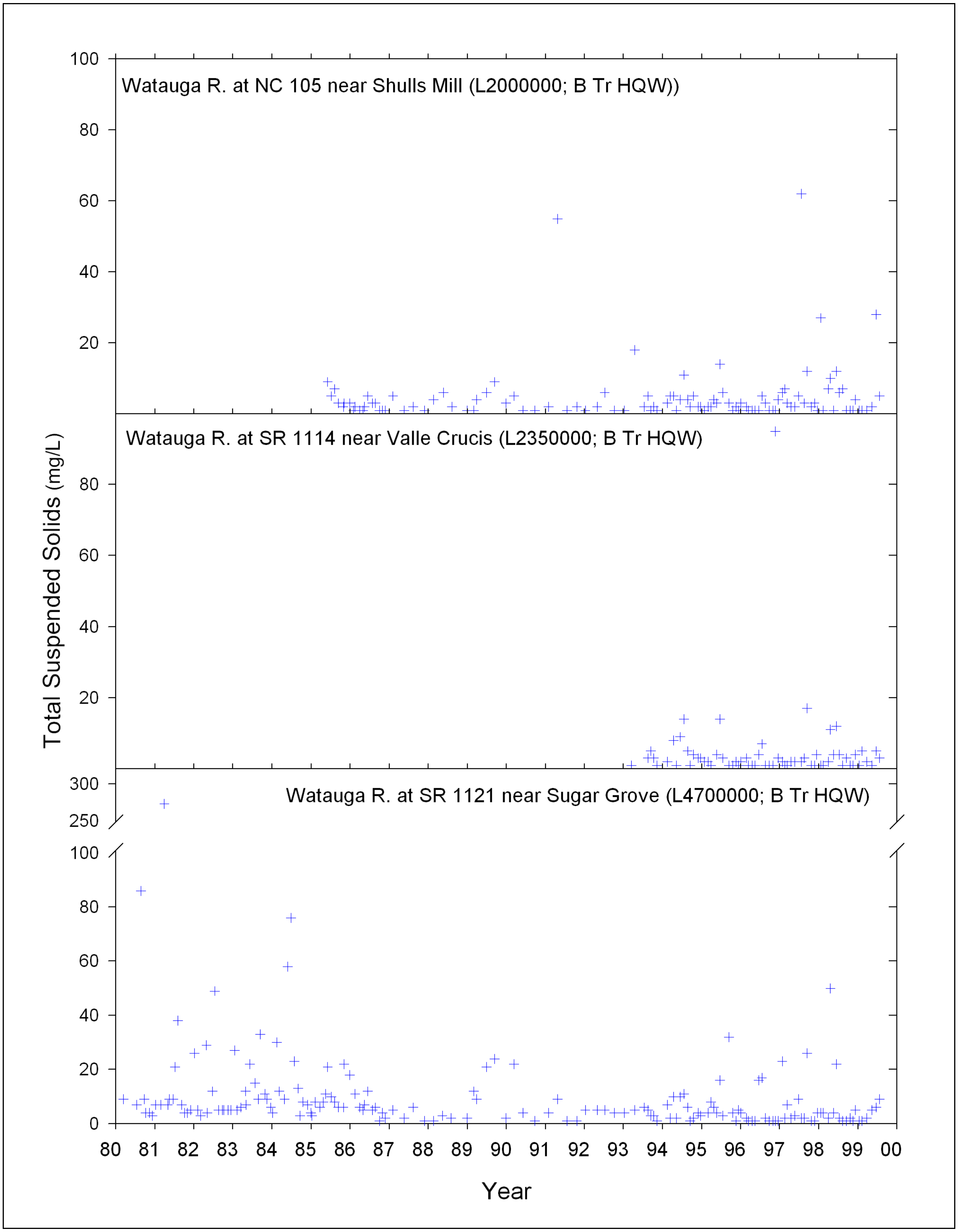

Figure 20. **Temporal patterns for total suspended solids in the Watauga River basin, 1980 - 1999.**

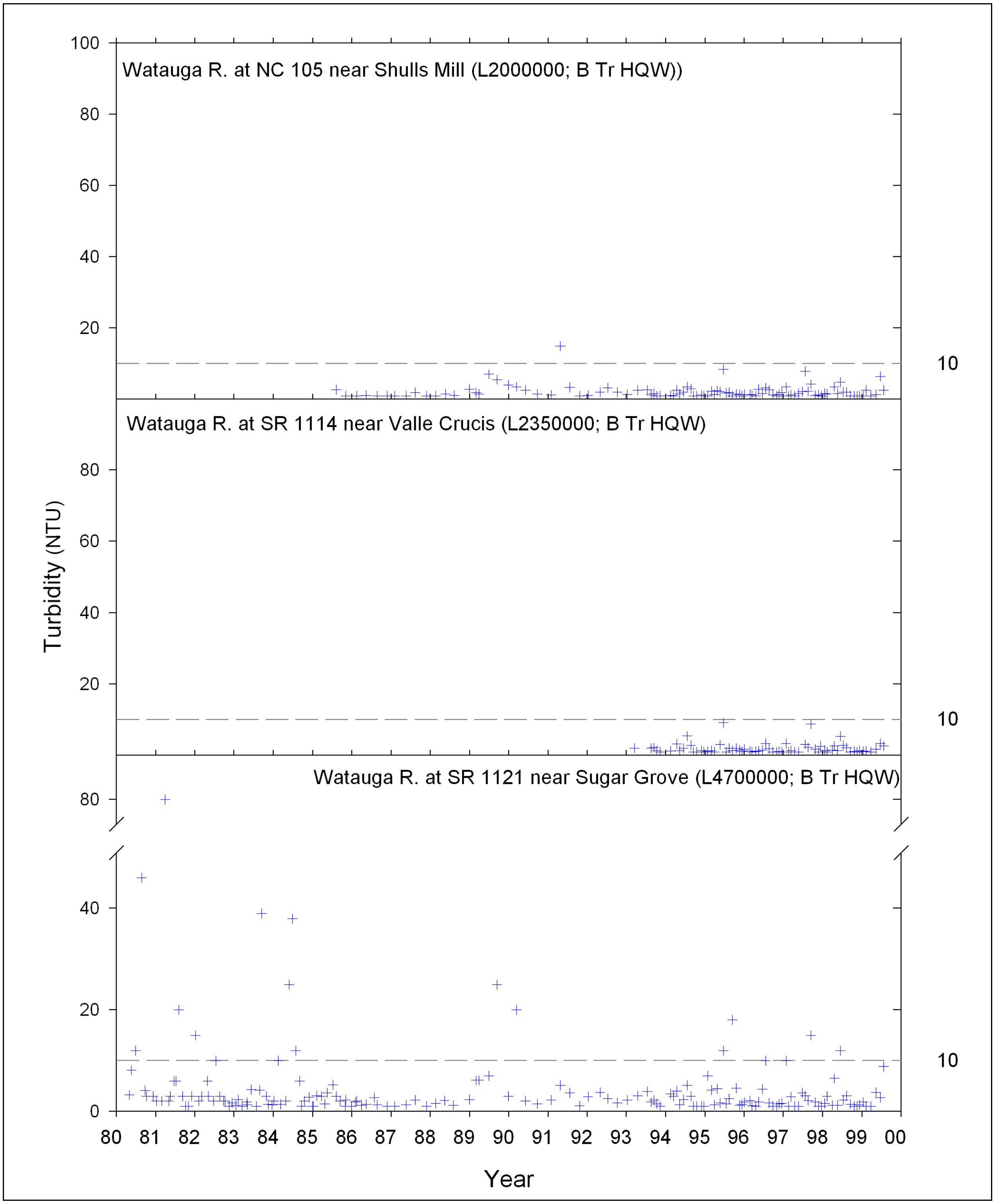

Figure 21. **Temporal patterns for turbidity in the Watauga River basin, 1980 - 1999. Dashed line represents the standard (10 NTU) for trout waters.**

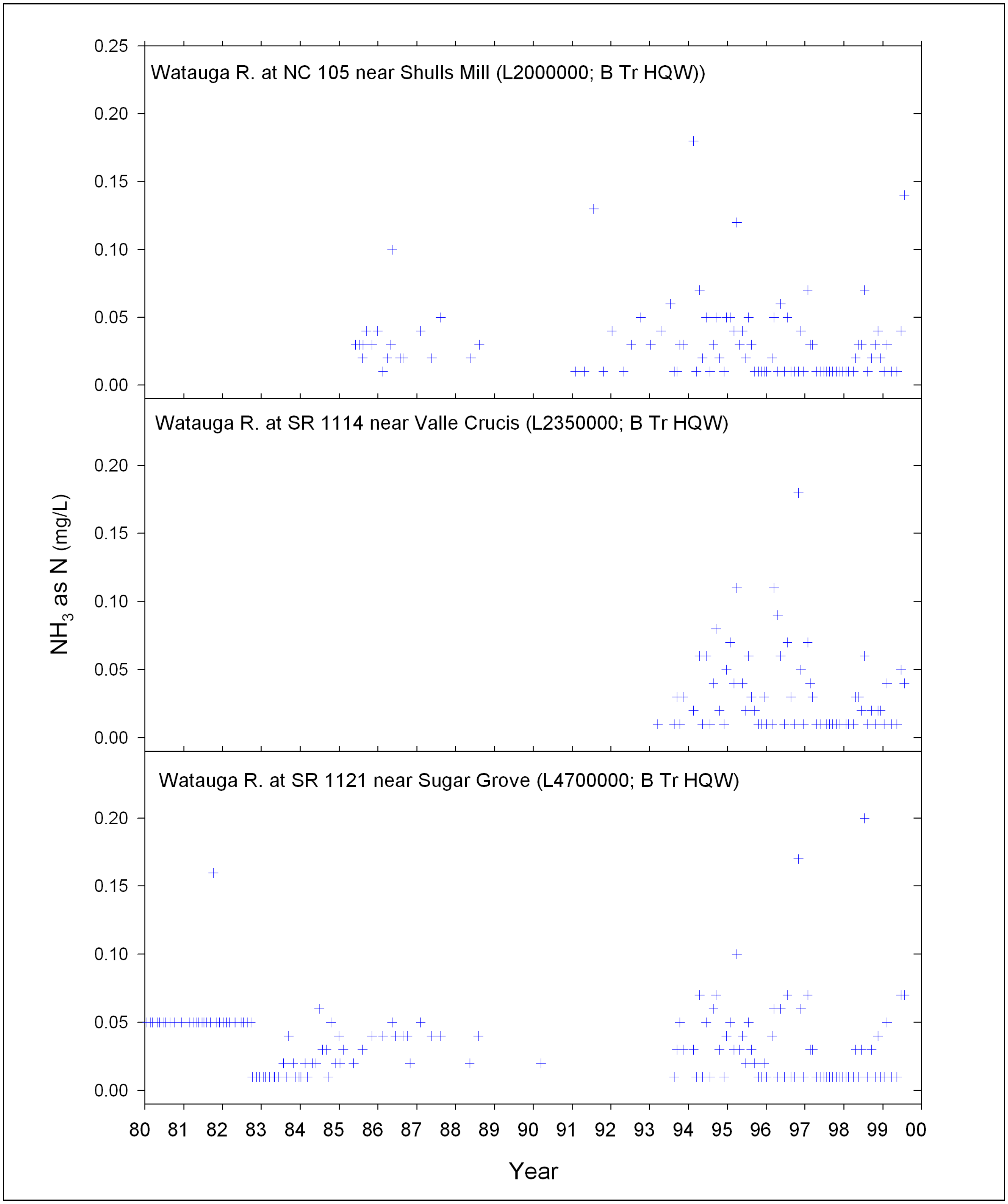

Figure 22. Temporal patterns for ammonia (NH_3) as nitrogen in the Watauga River basin, 1980 - 1999.

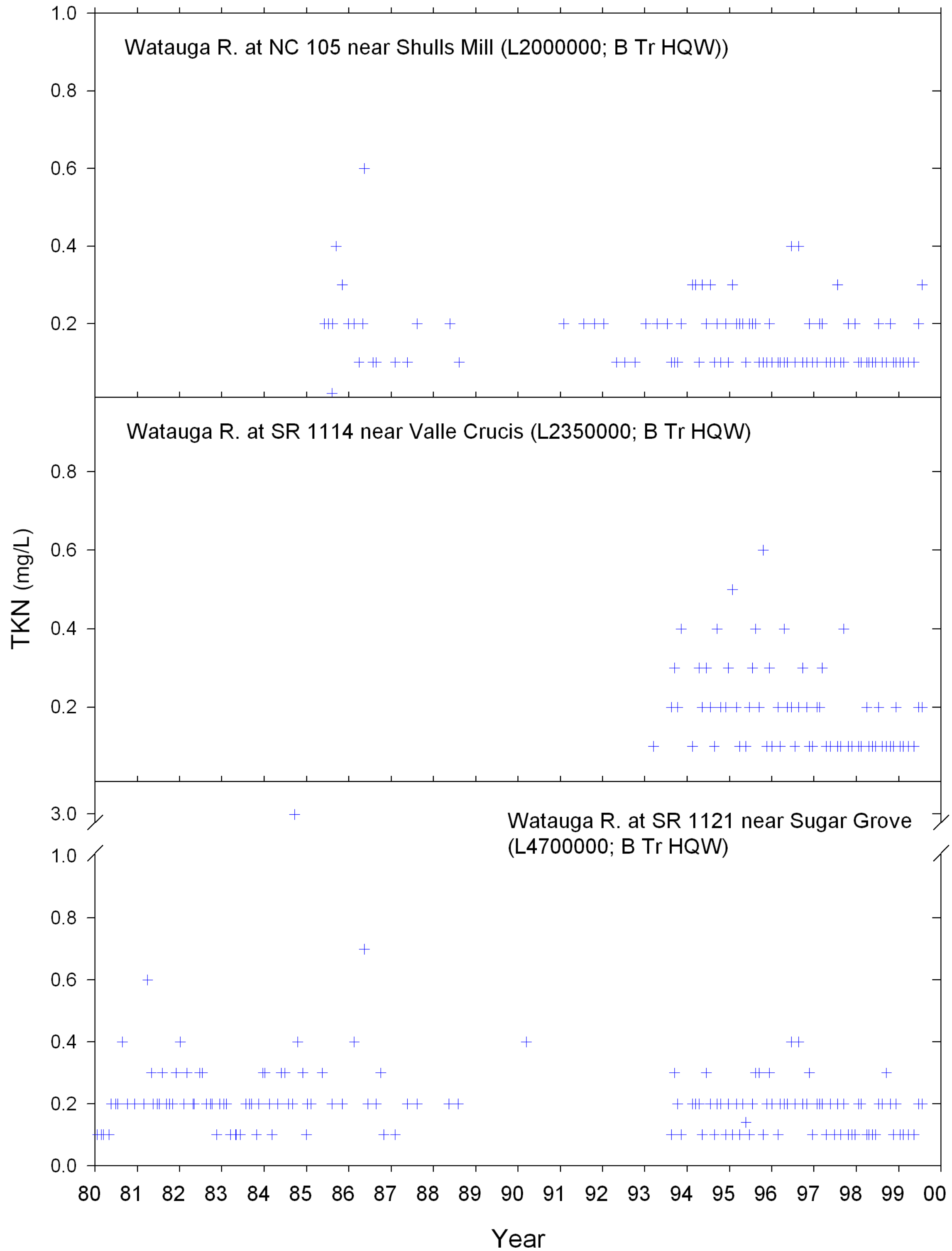

Figure 23. **Temporal patterns for total Kjeldahl (TKN) nitrogen in the Watauga River basin, 1980 - 1999.**

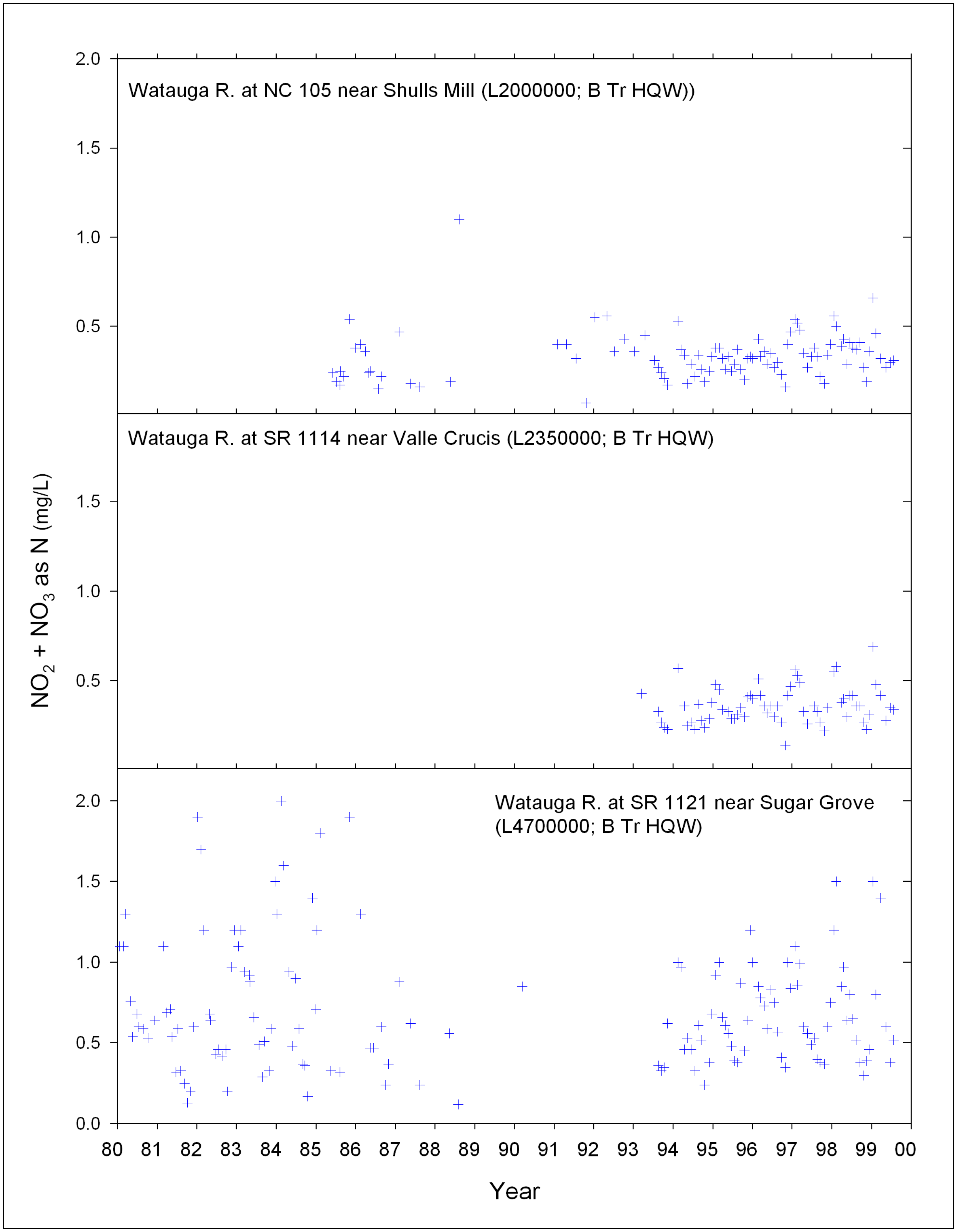

Figure 24. **Temporal patterns for nitrite+nitrate (NO_2+NO_3) nitrogen in the Watauga River basin, 1980 - 1999.**

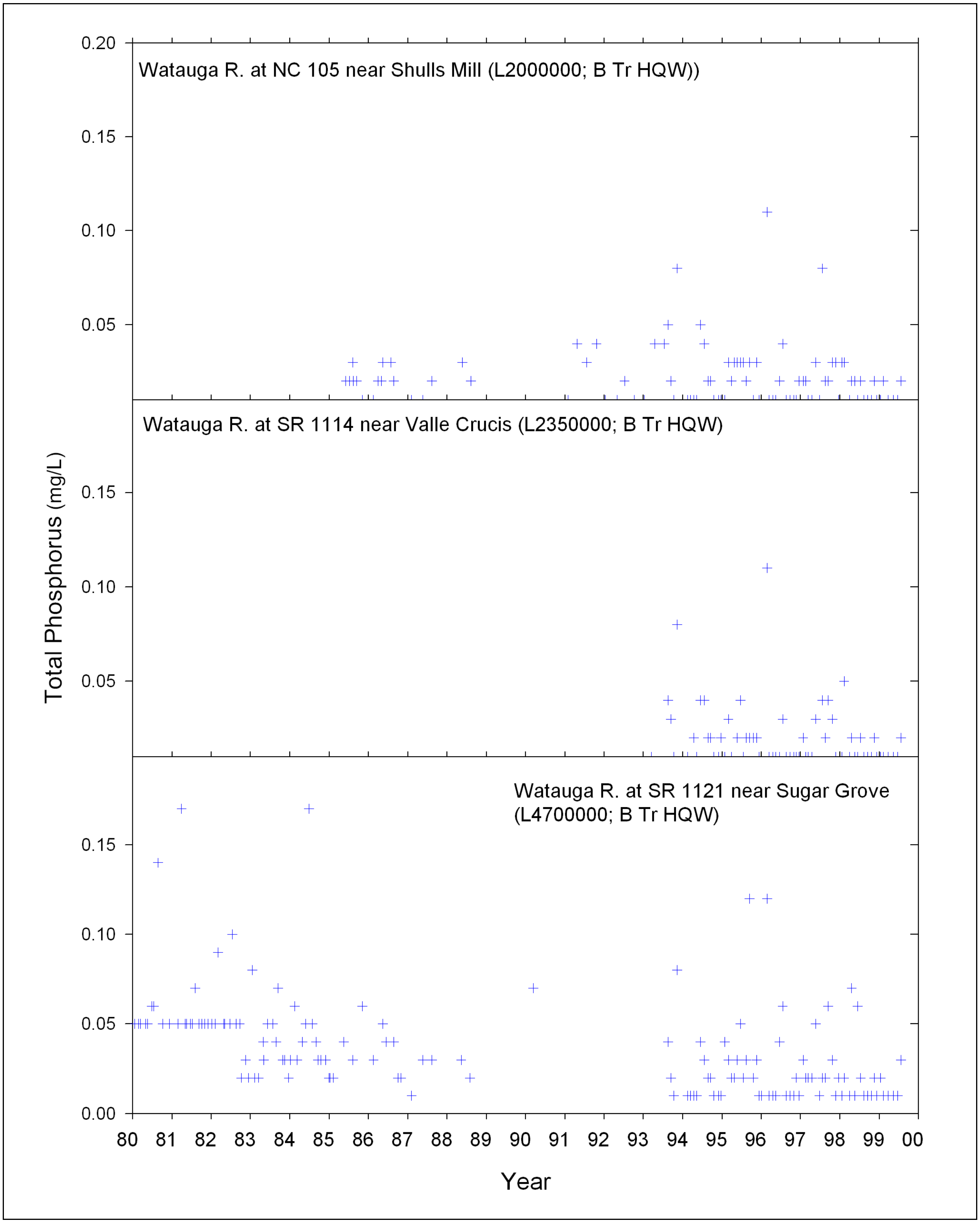

Figure 25. Temporal patterns for total phosphorus in the Watauga River basin, 1980 - 1999.

AQUATIC TOXICITY MONITORING

Two facilities in the Watauga River basin have NPDES permits which require whole effluent toxicity (WET) monitoring. These facilities are the Beech Mountain (Pond Creek) and Sugar Mountain Utilities (Figure 27 and Table 14). Each facility also has a WET permit limit.

These are the only two facilities monitoring for whole effluent toxicity in this basin since 1987, the first year that whole effluent toxicity limits were written into permits in North Carolina. Their compliance rates have fluctuated over time, but since 1991, the rates have been greater than 90% (Figure 28).

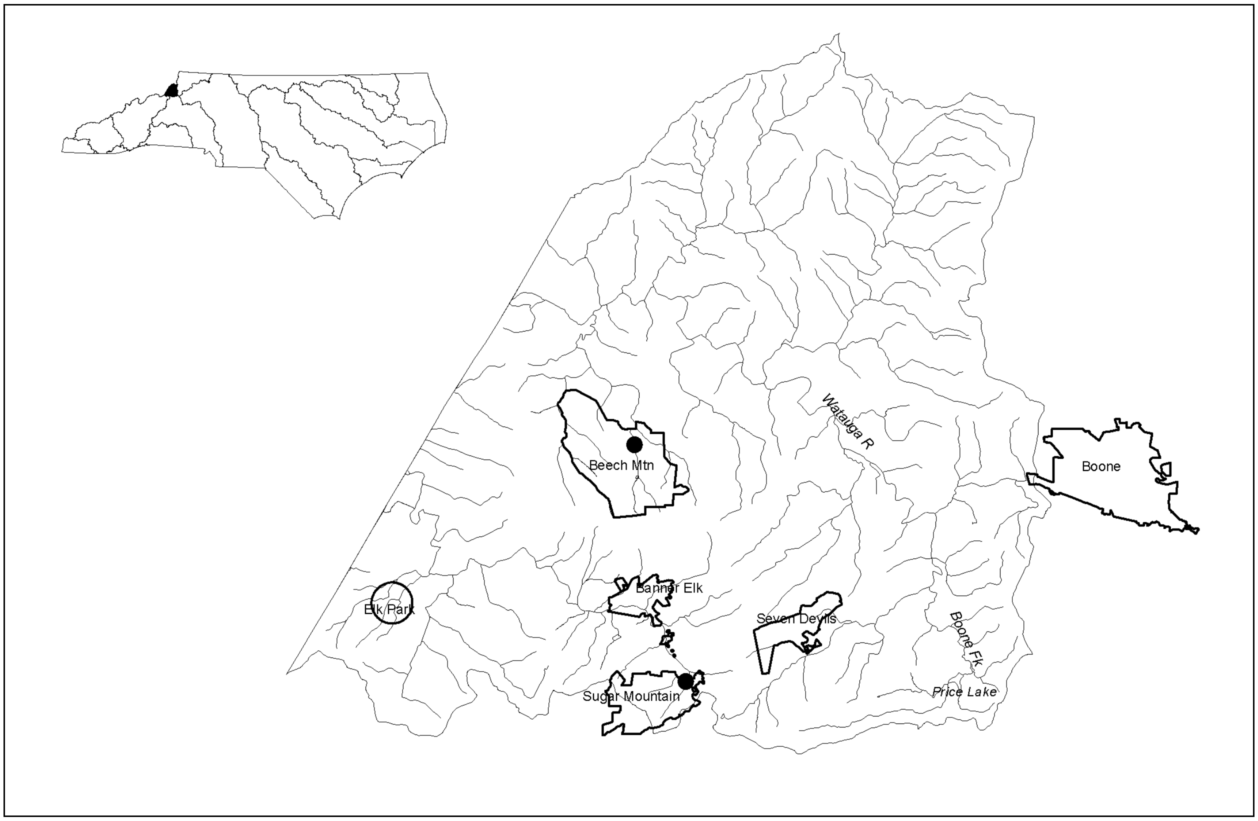

Figure 27. Location of facilities in the Watauga River basin required to perform whole effluent toxicity testing.

Table 14. Facilities in the Watauga River basin required to perform whole effluent toxicity testing and their compliance record.

Facility	Beech Mountain (Pond Creek)	Sugar Mountain Utilities
NPDES Permit No.	NC0069761/001	NC0022900/001
Receiving stream	Pond Creek	Flattop Cr
County	Watauga	Avery
Permitted flow (MGD)	0.400	0.500
7Q10	0.060	0.300
IWC[1] (%)	51	72
Pre-1999 passes[2]	22	44
Pre-1999 fails	4	8
1999 passes[2]	4	4
1999 fails	2	0

[1]Instream waste concentration.
[2]Note that "pass" denotes meeting a permit limit or, for those facilities with a monitoring requirement, meeting a target value. The actual test result may be a "pass" (from a pass/fail acute or chronic test), LC_{50}, or chronic value. Conversely, "fail" means failing to meet a permit limit or target value.

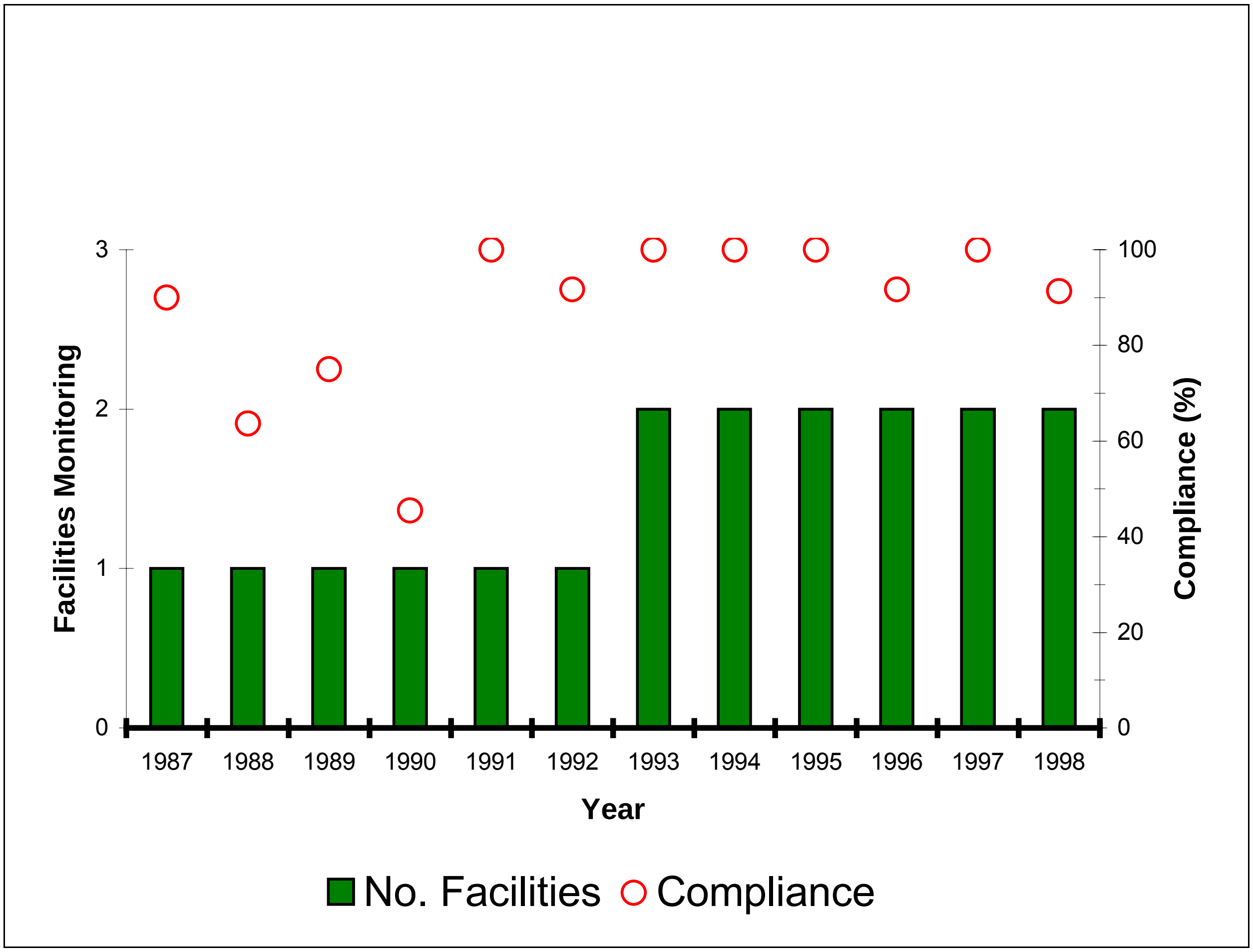

Figure 28. Compliance record of facilities in the Watauga River basin required to perform whole effluent toxicity testing, 1987 - 1998. The compliance values were calculated by determining whether a facility was meeting its ultimate permit limit during the given time period, regardless of any SOCs in force.

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GLOSSARY

7Q10	A value which represents the lowest average flow for a seven day period that will recur on a ten year frequency. This value is applicable at any point on a stream. 7Q10 flow (in cfs) is used to allocate the discharge of toxic substances to streams.
Bioclass	Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample based on the number of taxa present in the intolerant groups (EPT) and the Biotic Index value.
cfs	Cubic feet per second, generally the unit in which stream flow is measured.
CHL *a*	Chlorophyll *a*.
Division	The North Carolina Division of Water Quality.
D.O.	Dissolved Oxygen.
Ecoregion	An area of relatively homogeneous environmental conditions, usually defined by elevation, geology, and soil type. Examples include mountains, piedmont, coastal plain, sandhills, and slate belt.
EPT	The insect orders (Ephemeroptera, Plecoptera, Trichoptera); as a whole, the most intolerant insects present in the benthic community.
EPT N	The abundance of Ephemeroptera, Plecoptera, Trichoptera insects present, using values of 1 for Rare, 3 for Common and 10 for Abundant.
EPT S	Taxa richness of the insect orders Ephemeroptera, Plecoptera and Trichoptera. Higher taxa richness values are associated with better water quality.
HQW	High Quality Waters.
IWC	Instream Waste Concentration. The percentage of a stream comprised of an effluent calculated using permitted flow of the effluent and 7Q10 of the receiving stream.
Major Discharger	Greater than or equal to one million gallons per day discharge (≥ 1 MGD).
MGD	Million Gallons per Day, generally the unit in which effluent discharge flow is measured.
Minor Discharger	Less than one million gallons per day discharge (< 1 MGD).
NPDES	National Pollutant Discharge Elimination System.
NCBI (EPT BI)	North Carolina Biotic Index, EPT Biotic Index. A summary measure of the tolerance values of organisms found in the sample, relative to their abundance. Sometimes noted as the NCBI or EPT BI.
NCIBI	North Carolina Index of Biotic Integrity (NCIBI); a summary measure of the effects of factors influencing the fish community.
NSW	Nutrient Sensitive Waters.
NTU	Nephelometric Turbidity Unit.

GLOSSARY (continued)

ORW	Outstanding Resource Waters.
Parametric Coverage	A listing of parameters measured and reported.
SOC	A consent order between an NPDES permittee and the Environmental Management Commission that specifically modifies compliance responsibility of the permittee, requiring that specified actions are taken to resolve non-compliance with permit limits.
Total S (or S)	The number of different taxa present in a benthic macroinvertebrate sample.
UT	Unnamed tributary.
WWTP	Wastewater treatment plant.
Web Sites	Basinwide planning -- http://h2o.enr.state.nc.us/basinwide/basinwide/default.html
	Biological monitoring -- http://www.esb.enr.state.nc.us/bau.html
	Fish kills -- http://www.esb.enr.state.nc.us/fishkill/fishkill00.html
	North Carolina Administrative Code that relates to the Division of Water Quality and water quality protection -- http://h2o.enr.state.nc.us/rules/ruleindex.html

Appendix B1. Benthic macroinvertebrate sampling and criteria for freshwater wadeable and flowing waters.

Benthic macroinvertebrates can be collected using two sampling procedures. The Division's standard qualitative sampling procedure includes 10 composite samples: two kick-net samples, three bank sweeps, two rock or log washes, one sand sample, one leafpack sample, and visual collections from large rocks and logs (NCDEHNR 1997b).

An abbreviated method (4-sample EPT) includes one kick-net sample, one bank sweep, one leaf pack sample, and visual collections from large rocks and logs. Only EPT groups are collected and identified, and only EPT criteria are used to assign a bioclassification. "EPT" is an abbreviation for Ephemeroptera + Plecoptera + Trichoptera, insect groups that are generally intolerant of many kinds of pollution. Higher EPT taxa richness values usually indicate better water quality.

The purpose of these collections is to inventory the aquatic fauna and produce an indication of relative abundance for each taxon. Organisms are classified as Rare (1-2 specimens), Common (3-9 specimens), or Abundant (≥ 10 specimens).

Several data-analysis summaries (metrics) can be produced to detect water quality problems (Table B1).

Table B1. Benthos classification criteria for flowing water systems in the mountain ecoregion.

Metric	Sample type	Bioclass	Score
EPT S	10-sample Qualitative	Excellent	> 41
		Good	32 - 41
		Good-Fair	22 - 31
		Fair	12 - 21
		Poor	0 - 11
	4-sample EPT	Excellent	> 35
		Good	28 - 35
		Good-Fair	19 - 27
		Fair	11 - 18
		Poor	0 - 10
Biotic Index (range 0 – 10)	10-sample Qualitative	Excellent	< 4.05
		Good	4.06 - 4.88
		Good-Fair	4.89 - 5.74
		Fair	5.75 - 7.00
		Poor	> 7.00

These metrics are based on the idea that unstressed streams and rivers have many invertebrate taxa and are dominated by intolerant species. Conversely, polluted streams have fewer numbers of invertebrate taxa and are dominated by tolerant species. The diversity of the invertebrate fauna is evaluated using taxa richness counts; the tolerance of the stream community is evaluated using a biotic index.

EPT taxa richness (EPT S) is used with criteria to assign water quality ratings (bioclassifications). Water quality ratings also are based on the relative tolerance of the macroinvertebrate community as summarized by the North Carolina Biotic Index (NCBI). Tolerance values for individual species and the final biotic index values have a range of 0-10, with higher numbers indicating more tolerant species or more polluted conditions.

Water quality ratings assigned with the biotic index numbers are combined with EPT taxa richness ratings to produce a final bioclassification, using criteria for Mountain streams. EPT abundance (EPT N) and total taxa richness calculations also are used to help examine between-site differences in water quality. If the EPT taxa richness rating and the biotic index differ by one bioclassification, the EPT abundance value is used to determine the final site rating.

The expected EPT taxa richness values are lower in small high-quality mountain streams (< 4 m wide or with a drainage area < 3.5 mi^2). For these small mountain streams, an adjustment to the EPT taxa richness values is made prior to applying taxa richness criteria.

EPT taxa richness and biotic index values also can be affected by seasonal changes. Criteria for assigning bioclassification are based on summer sampling: June-September. For samples collected outside summer, EPT taxa richness can be adjusted by subtracting out winter/spring Plecoptera or other adjustment based on resampling of summer site. The biotic index values also are seasonally adjusted for samples outside the summer season.

Criteria have been developed to assign bioclassifications ranging from Poor to Excellent to each benthic sample. These bioclassifications primarily reflect the influence of chemical pollutants. The major physical pollutant, sediment, is not assessed as well by a taxa richness analysis.

Flow measurement

Changes in the benthic macroinvertebrate community are often used to help assess between-year changes in water quality. Some between-year changes in the macroinvertebrates, however, may be due largely to changes in flow. High flow years magnify the potential effects of nonpoint source runoff, leading to scour, substrate instability, and reduced periphyton. Low flow years may accentuate the effect of point source dischargers by providing less dilution of wastes. For these reasons, all between-year changes in the biological communities are considered in light of flow conditions (high, low, or normal) for one month prior to the sampling date. Daily flow information is obtained from the closest available USGS monitoring site and compared to the long-term mean flows. High flow is defined as a mean flow > 140% of the long-term mean for that time period, usually July or August. Low flow is defined as a mean flow < 60% of the long-term mean, while normal flow is 60-140% of the mean. While broad scale regional patterns are often observed, there may be large geographical variation within the state, and large variation within a single summer period.

Appendix B2. **Benthic macroinvertebrate data collected in the Watauga River basin, 1983-1999. Current basinwide monitoring sites have the Map No. bolded.**

Subbasin/ Stream	Location	County	Map No.[1]	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class[1]
Watauga R	SR 1339	Avery	B-1	8-(1)	07/88	-/38	-/1.70	E
					08/85	61/33	3.25/1.94	E
Watauga R	SR 1594	Watauga	B-2	8-(1)	03/90	-/40	-/1.89	G
					07/88	83/44	3.35/2.58	E
					08/85	67/34	3.40/2.64	E
Watauga R	SR 1580	Watauga	**B-3**	8-(1)	07/99	-/25	-/3.90	G-F
					08/94	-/38	-/3.28	E
					07/88	-/38	-/3.16	E
					08/85	76/32	4.64/3.51	G
Watauga R	NC 105	Watauga	**B-4**	8-(1)	07/99	88/42	3.91/3.38	E
					08/94	74/41	3.91/3.31	E
					03/90	99/57	3.32/2.60	E
					08/89	104/46	3.97/3.18	E
					07/88	-/45	-/2.71	E
					08/87	93/45	4.11/2.91	E
					08/85	84/45	4.27/3.06	E
Valley Cr	NC 105	Watauga	B-5	8-4	07/99	-/23	-/1.89	NR
					03/90	-/29	-/1.90	NR
Spice Bottom Cr	SR 1560	Watauga	B-6	8-5-1	03/90	-/38	-/2.76	G
Boone Fk	SR 1561	Watauga	**B-7**	8-7	07/99	72/39	2.59/1.61	E
					08/94	59/37	2.44/1.78	E
					11/89	-/42	-/1.59	E
Boone Fk (below lake)	off SR 1558	Watauga	**B-8**	8-7	07/99	-/32	-/2.84	G
					08/94	-/31	-/2.68	G
					03/90	-/45	-/2.27	E
Lance Cr (above golf course)		Watauga	B-9	8-8-(1)	03/90	-/33	-/1.88	E
Lance Cr (in golf course)		Watauga	B-10	8-8-(2)	03/90	-/27	-/2.39	G-F
Laurel Fk	SR 1111	Watauga	**B-11**	8-10	07/99	-/27	-/3.27	G-F
					09/94	-/24	-/3.36	G-F
					03/90	-/31	-/2.71	G
Dutch Cr	off NC 105	Watauga	B-12	8-12-(3.5)	07/88	87/38	4.62/3.41	G
Cove Cr	SR 1305	Watauga	B-13	8-15	07/88	-/33	-/3.46	G
Cove Cr	US 321	Watauga	**B-14**	8-15	07/99	-/32	-/3.35	G
					08/94	-/30	-/3.62	G
Watauga R	NC 194	Watauga	B-15	8-(16)	03/90	93/51	3.80/2.83	E
Watauga R	SR 1121	Watauga	**B-16**	8-(16)	07/99	81/38	4.27/3.47	G
					08/94	87/42	4.28/3.52	G
					07/90	101/48	4.73/3.70	E
					07/88	105/46	4.93/3.40	G
					07/86	101/45	5.00/3.57	G
					08/85	88/40	4.82/3.64	G
					08/84	99/41	4.88/3.32	G
					08/83	94/40	4.81/3.63	G
Watauga R	SR 1200	Watauga	**B-17**	8-(16)	07/99	94/50	3.89/3.22	E
					08/94	97/46	3.71/2.89	E
					07/88	86/38	4.66/3.07	G
Laurel Cr	off SR 1123	Watauga	**B-18**	8-17	07/99	-/31	-/2.59	G
Beaverdam Cr	SR 1201	Watauga	**B-19**	8-19	07/99	-/37	-/3.17	G
					08/94	-/32	-/2.61	G
Beech Cr (above Pond Cr)		Watauga	B-20	8-20	09/87	53/29	2.59/1.41	G
Beech Cr (below Pond Cr)	SR 1126	Watauga	B-21	8-20	09/87	54/30	2.95/1.57	G
Beech Cr (above Poga Cr)	US 321	Watauga	**B-22**	8-20	07/99	-/38	-/2.50	E
					08/94	94/46	3.26/2.52	E
Pond Cr (above WWTP)		Watauga	B-23	8-20-2	09/87	54/29	3.05/1.44	E
Pond Cr (near mouth)		Watauga	B-24	8-20-2	09/87	41/24	2.77/1.50	G
Buckeye Cr (headwaters)		Watauga	B-25	8-20-3-(0.5)	04/84	48/26	3.08/1.74	G
Buckeye Cr (above Grassy Gap Cr)		Watauga	B-26	8-20-3-(1.5)	04/84	50/29	2.45/1.79	G
Buckeye Cr	SR 1312	Avery	B-27	8-20-3-(2.5)	04/84	59/31	2.93/1.73	G

Appendix B2 (continued).

Subbasin/ Stream	Location	County	Map No.[1]	Index No.	Date	S/ EPT S	NCBI EPT BI	Bio Class[1]
Elk R (below SR 1337)	off NC 184	Avery	**B-28**	8-22-(3)	07/99	102/44	4.37/3.58	G
					08/94	77/33	4.80/4.49	G
Elk R (below Banner Elk)	SR 1326	Avery	B-29	8-22-(3)	08/94	76/33	4.12/3.33	G
Elk R	SR 1305	Avery	**B-30**	8-22-(14.5)	07/99	88/44	3.93/3.16	E
					08/94	-/36	-/3.08	E

[1] E = Excellent, G = Good, G-F = Good-Fair, F = Fair, and NR = not rated.